POWER PLANT ENGINEERING

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R. E. TURNER, Managing Editor
A. W. KRAMER, Associate Editor
CHESTER R. EARLE, Associate Editor
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Modern Facilities

NOTHING LIKE a good laboratory to carry on intensive research and as No. 1 of our series on Research Romances we offer the above. This was discovered after years of foreign exploration by our Special Foreign Research Investigator, J. J. McDougall.

The laboratory is of a type introduced in Mexico by the Spanish scientists shortly after the explorations of Cortez. It is extremely modern with running water all over the place (whenever it rains), solid wheels (with a squeak), wide tread tires (with a spare), reliable power facilities (a hay burner) and a director so collegiate that he wears a Princeton beer suit.

It is difficult to understand how those ancient scientists, knowing only that gold and silver were the magic words that opened the Ali Baba cave to civilized countries, accomplished so much with such crude equipment.

Yet the situation is not greatly different from the early state of pulverized coal as a power plant fuel. A few years ago pulverized fuel was introduced and became a success. Even though harrassed by a civil war between the centralized pulverizer and direct firing factions, progress was rapid. In spite of this progress, little was actually known about the actual combustion conditions in the furnace.

Little by little information has been collected by a few investigators. Among these E. H. Tenney has played an important part and a summary of his recent work on investigation of combustion conditions as effected by methods of firing is given on page 376. After all, it is the performance in the furnace in which we are interested and Mr. Tenney has used two large furnaces in Cahokia Station as his main laboratory.

Aren't you interested in knowing how long combustion takes? How hot certain parts of the furnace are? How fast the gasses move from the time they leave the burner until they reach the tubes? How the CO_2 varies in different places? Mr. Tenney answers all these questions.

WITH THE EDITORS

The Concept of Beauty as Related to Engineering

We hear much these days about the degrading effect of our materialistic era upon human values, of the demoralizing influence of our machine age upon our esthetic sense. Indeed, it is common belief in many quarters that engineering is inevitably unesthetic in its aims, methods and accomplishments. Many believe that the primitive, open and savage country with few and scattered habitations makes essentially for beauty; while on the contrary engineering necessarily associates with crowded houses, smoky chimneys, ugly factories and hopelessly repulsive surroundings.

Unquestionably there is some ground for the belief. Many things associated with engineering, particularly in the past, are undeniably ugly. Commercial developments in numerous instances have disfigured large areas of the earth's surface and have polluted the atmosphere with smoke, dust and fumes. But the contrary also is true; there is much in engineering that is beautiful—not necessarily the kind of beauty which Joseph Pennel saw in the stacks and smoke of the Pittsburgh steel mills but a type of beauty that appeals to our sense of finer values. As a matter of fact, the ugliness and unshapeliness which we attribute to engineering is more often the result of lack of engineering than due to its application. If, in the past, engineering enterprises have produced smoke and dirt, remember also that engineering has shown how to eliminate smoke and dirt.

Engineering, to be sure, is utilitarian in its purpose but, as has often been proved, an engineering achievement while possessing the utilitarian element can at the same time be beautiful. A bridge for example is essentially utilitarian but often it is also a thing of beauty.

Now the interesting thing about this is that a bridge or a skyscraper, or a locomotive, is most beautiful when it is naturally so; when no distinct attempt is made to add to its beauty in any superficial manner. That was the trouble with our early skyscrapers. For thirty years we tried to make scyscrapers beautiful by camouflaging them with classical and conventional ornament, by finishing their exteriors as though they were built of masonry. Most of the results were ugly, often hideous. It was not until a Scandinavian architect taught us to discard our conventional notions and simply to hang a tight skin of stone around the steel skeleton that the natural beauty of the steel building was brought out.

This also is true of other products involving engineering, power plant structures for example. Since there has been a more or less distinct desire on the part of designers to make power plant buildings attractive, various attempts in that direction have shown that the most attractive power plant structures are those that are most natural. Attempts to impart beauty by disguising them as banks and art museums or mausoleums have not proved successful but those which have taken advantage of the inherent qualities of mass and proportion without using superficial ornament have attracted much favorable comment.

It is this "natural" beauty in engineering structures that it is the engineers' function to disclose. This beauty often is hidden; sometimes in the intricacies of a mathematical equation, sometimes in the suspension of a cable, again in the harmonious combination of the elements which naturally make up the structure. Sometimes a law, a legal restriction will determine physical appearance of a definite order. Thus the "step back" ordinance in New York has resulted in a definite type of architecture which in its better forms is decidedly attractive.

The concept of beauty in engineering is somewhat different from the concept of beauty in the arts; it is less imaginative, more removed from the primitive but is none the less pleasing. If, like the cultivation of a wild flower, it removes certain elements of wild beauty which appeal to our primitive nature, at the same time it replaces them with others of a more orderly and intellectual character—more in keeping with our intellectual civilization. Engineering, being based on mathematics and physics, tends to spell out those unchanging laws of nature which are the glory of the universe and the appreciation of which awakens a new sense of beauty and reverence. Being administered through the principles of economics, it tends to keep the true and beautiful linked with the affairs of life.

Hand-Made Products in a Machine Age

That the product of the machine is sometimes inferior to the corresponding hand-made product is distinctly not the fault of the machine but of the civilization that owns it, as we have repeatedly pointed out. Social cachet attaches to hand-made products, in the minds of many people and, without question, this is sometimes justified. In many cases, however, the superiority of the hand-made product lies not so much in the method of fabrication as in the skill, originality and artistry of the designer, whose aim is often to design an object that nobody else will desire or attempt to duplicate and that will have high value because of its very uniqueness.

The whole subject is worth some study by engineers interested in the social implications of our present industrial development. Probably as many candles are made today as the world required 100 yr. before the incandescent lamp, according to the Industrial Bulletin of Arthur D. Little, Inc. The manufacture of hooked rugs and antique furniture still goes on. Strangely enough, paper making by hand continues as an extensive industry in many countries, says the Bulletin and has recently been revived in Ohio and Connecticut. Drawing and filter papers, high grade stationery, book and cover papers for special and *de luxe* editions are still hand-made.

In view of the present decentralization of power—that is, the ability to make or buy cheap power almost anywhere in the country—and the possible effect of this on our future industrial development, engineers will be at least interested and often benefited by a study of how many handicrafts flourish vigorously in this age of the machine.

Suggestions for Profitable Reading

1 Example = 10 Sermons

This interesting equation, familiar to all engineers, has been previously discussed in these pages but whenever we find additional data that will satisfy it, that only serves to strengthen the proof. If you are interested in the derivation of the equation, you will understand some of the factors involved by starting with the following fundamental equation and working it out for yourself:

$746\ E^2 + 10\ Q + 259\ C = 1000\ W + \sqrt{469\ T} + 972\ S$

in which E = enterprise, in ergs; Q = design, equipment and performance in per cent; C = coöperation in degrees Baume'; W = wind velocity in feet per second, T = theories in degrees Twaddle and S = condescension in epigrams.

After putting in the proper values and rationalizing, you will find that this equation works out, just as we said, to the form first given.

Now on the next page you will find a practically perfect example that satisfies this equation. For a long time Power Plant Engineering has been maintaining that good physical condition and continuity of operation of a power plant do not constitute definite proof that the plant cannot be profitably revamped. It is possible that reiteration has made this statement sound somewhat like a sermon but in fact, it was not so intended. It was, rather, a definite conclusion drawn from observation of many industrial plants and central stations and from rather intimate contact with the important developments in power plant design, equipment and performance that have occurred during the past 10 yr.

Power Plant Engineering has published a number of articles showing just how this rehabilitation was carried out under such widely different industrial conditions as those of Youngstown Sheet & Tube Co. and Champion International Co., to mention only two cases. In this issue, as we said before, Mr. Bryan gives the details of the power plant rehabilitation program carried out by Chas. T. Main, Inc. for Hollingsworth & Whitney Co., paper manufacturers. This case fits the general thesis like a glove. It provides further evidence that now is the time to consider carefully the matter of lowering power costs, at a time when it can be done effectively, to forestall obsolescence and to get ready for the intense competition that lies ahead.

How Oily Should Tongue Oil Be?

That question, it has been suggested, might well be referred for answer to the politicians who are beginning to stock up with copious supplies of that oil for use during the coming campaign. Without doubt they follow the latest practice and buy their oils according to carefully drawn specifications. Can't you visualize the prospective orator opening the deep right-hand drawer of his desk and drawing forth neat manila folders labeled Oil, Tongue, Specification for, No. A-208-J6 or Oil, Banana, Specification for, No. Z-1001-A42, or Oil, Tonsil and Oil, Esophagus. Well the forthcoming conventions of the two great parties will tell whether the oil specifications have been correctly drawn or not.

The engineer, on the other hand, has little interest in Oil, Banana, or Oil, Tongue but much in Oil, Lubricating. It's a good plan to know what you buy and specifications help, provided you know how and what to specify and how to find out if you get what you specified. In regard to lubricating oil, however, Mr. Newman in this issue raises the question of the relation of specifications, as ordinarily drawn, to good lubricating value. Should the principal characteristic of oil be oiliness or should it be something else? What is oiliness, anyway? What makes good lubricating value and how can it be tested for a given case? Mr. Newman may give you some new ideas on buying oil to get lubrication rather than physical properties.

Can You Make Rabbit Stew?

One of the best recipes for rabbit stew is that given by a famous French chef who said that in making this stew he used rabbit and horse in equal proportions—one rabbit, one horse. First, however, you must get a good rabbit. Well, do your bucket conveyors jackrabbit? Get the rabbit out and there you are. Mr. Lee explains in this issue how this may be done. If you know how, not only will you save yourself a lot of grief, present and future, but also you will have a rabbit all ready to go into the stew.

Don't However, Get Into a Stew About Oil Engine Power Costs

For assistance is at hand. Every year more and more assistance is being made available to those who are wondering whether their present oil engine costs are too high or are trying to figure out what the costs of a new installation are likely to be. For several years, the Oil Engine Power Committee of the A.S.M.E. and the General Power Committee of the N.E.L.A. have been accumulating such cost data until now a most imposing array of figures is available to help in analyzing these costs. Of course, a great deal more information will be needed, yet much can be done with what we now have.

For example, the latest report of the N.E.L.A. General Power Committee on Diesel power costs, abstracted in this issue, gives operating costs and investment costs of 266 plants with a total of 412,000 installed horsepower and an annual output of 698,000,000 kw-hr. Besides this, the report discusses in detail the proper methods of calculating power cost. Obviously it is incorrect to compare your costs with those of just a few other plants. But by taking from the report the data for a number of plants whose size, load conditions and other factors are comparable to yours, you can get a basis for comparison that is so much better than a guess that it can properly be called engineering judgment. This report constitutes a real service to the engineering field and will be of interest to you whether you have to deal with Diesel plants or not.

POWER PLANT ENGINEERING May 1 1932

Rehabilitation Lowers P

for Hollingsworth & Whitney Co.

By MARCUS K. BRYAN
Chas. T. Main, Inc.

Good physical condition and reliable operation are no longer proof that a power plant cannot be profitably revamped. Truth of this statement is shown by the results of the rehabilitation of the plant of a large paper mill at Winslow, Me. These results include reduction of operating costs, elimination of purchased power, improved reliability and flexibility, elimination of chimney dirt discharge and release of valuable space for process work

DEVELOPMENTS in the steam plant field, which may be applied in the industrial power plant to reduce the cost of power and heat for manufacturing, have gone forward at such a rate during the past 10 yr. that the magnitude of this advancement and particularly its possibilities in application to the isolated plant are not generally appreciated. Obsolescence of power station machinery and operating methods has been increased materially by the developments which have matured in recent years. This applies particularly to the boiler plant, into which modern fuel burning and steam generating practice fit most directly and, to a lesser extent, although quite effectively in numerous plant setups, to the power generating equipment.

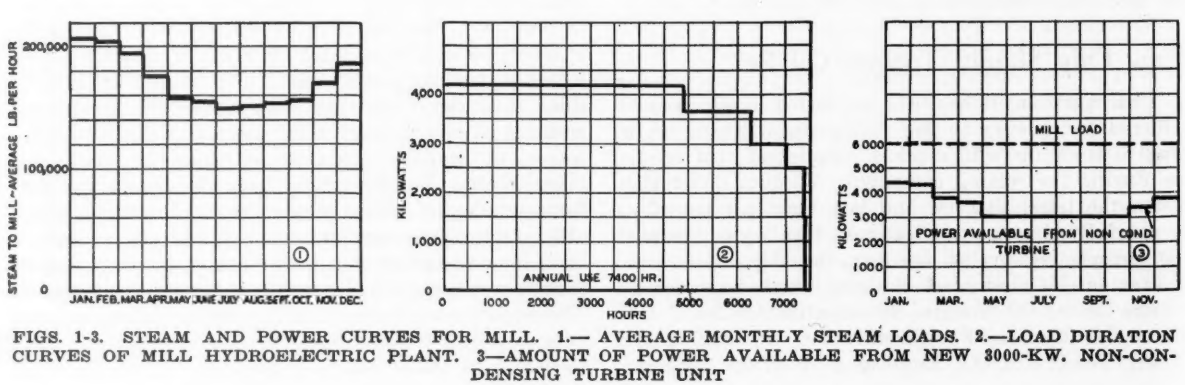
Good physical condition and reliable operation are no longer proof that a plant cannot be profitably revamped. Many plants in good operating condition are remodeled with undeniable economic justification from the point of view of generally improved operation and resultant lower costs.

Recent reconstruction of the steam plant at the Winslow, Maine, mill of the Hollingsworth & Whitney Co. illustrates the employment of modern designs to remodel a steam plant of good physical condition and performance. The improvements can be understood best from descriptions of the plant before and after it was remodeled.

Description of Plant in 1930

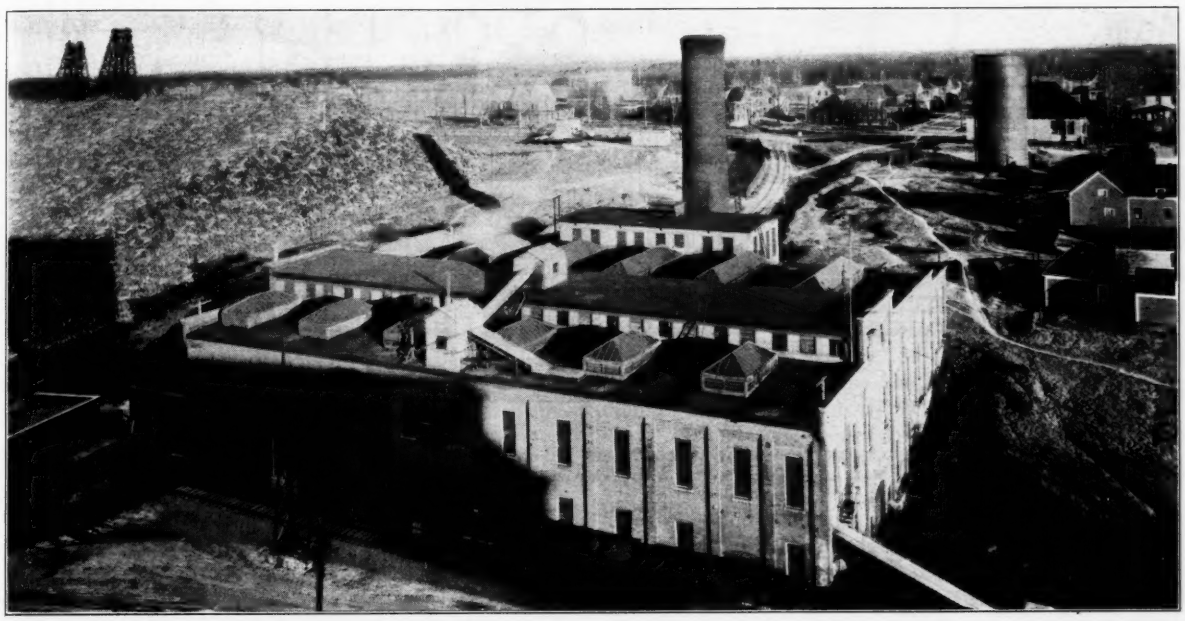
The mill is a complete paper-making plant, consisting of sulphite pulp mill, paper mill and finishing plant. Steam is required principally for cooking pulp, drying paper, space heating and the like, for six paper machine drives and for a few small pumps and air compressors. Electric motors drive the other machines and these consume the majority of the power.

Steam was generated at 120 lb. pressure in horizontal return tubular boilers. There were 35 of these boilers, totaling 6740 rated boiler horsepower. Seven of these boilers, rated 125 hp. each, were set with dutch oven furnaces and fired with wood waste. Steam



FIGS. 1-3. STEAM AND POWER CURVES FOR MILL. 1.— AVERAGE MONTHLY STEAM LOADS. 2.—LOAD DURATION CURVES OF MILL HYDROELECTRIC PLANT. 3—AMOUNT OF POWER AVAILABLE FROM NEW 3000-KW. NON-CONDENSING TURBINE UNIT

s Power Plant Costs



generated by these boilers was a small percentage of the total and variable in amount, being dependent upon wood room operation. In the same boiler room with the seven wood-burning boilers there were ten Jones stoker-fired h.r.t. boilers and, in another building, about 250 ft. across the mill yard, were the remaining 18 Jones stoker-fired h.r.t. boilers. These last-mentioned boilers were rated at 4615 hp. They were equipped with cast-iron economizers. Steam was generated in the coal-fired boilers with an efficiency of 68 to 70 per cent. Contributing to this performance was the light loading of the boilers and a liberal firing force.

Each boiler room had an overhead coal bunker. Coal was received in drop bottom cars and dropped from trestles into ground storage at the upper end of the mill yard some 600 yd. from the boiler rooms. Delivery to the boiler rooms was made in industrial cars, each of about 3-t. capacity, drawn across the yard by horses in trains of 3 to 5 cars. These cars were elevated one at a time to a track above the bunkers and there spotted and dumped by hand. A locomotive crane loaded the cars at the storage pile.

Graph of the average monthly steam loads is shown in Fig. 1. Normal sources of electric power supply were a hydroelectric installation at the mill and a hydroelectric plant downstream from the mill and not owned by the company, from which electricity was purchased. These supplies were supplemented when necessary with two condensing steam turbine generators, one of 750-kw. capacity and the other of 1250-kw. capacity, both installed in a room adjacent to the larger boiler plant. These turbine generators were maintained, without change, in the reconstructed system, to be used as standby and emergency equipment.

Power supplied by the various sources averaged annually as follows:

Mill Hydro Plants	28,900,000	kw-hr.
Condensing Turbines	3,000,000	"
Purchased Hydro	12,500,000	"
Total	44,400,000	kw-hr.

Variation in the power taken from these different sources, throughout the year, will be appreciated after an inspection of the load duration curve of the mill hydroelectric plant, shown in Fig. 2.

Summarizing, the rudiments of the steam and power system before reconstruction were:

(1) Ample steam generating capacity available in a large number of stoker-fired boilers installed in two houses, operated at 120 lb. pressure with better than ordinary efficiency and well maintained. Replacement was not a necessity.

(2) Reliable power supply from three sources with occasional flood conditions restricting the head on the wheels and requiring some curtailment of mill operations. This situation, although annoying, was not so serious as to have required correction. The sources of power were:

(a) a good hydroelectric development supplying about 65 per cent of the electricity

(b) an outside source from which about 28 per cent of the needed electricity was purchased for a unit cost which in many situations would be attractive

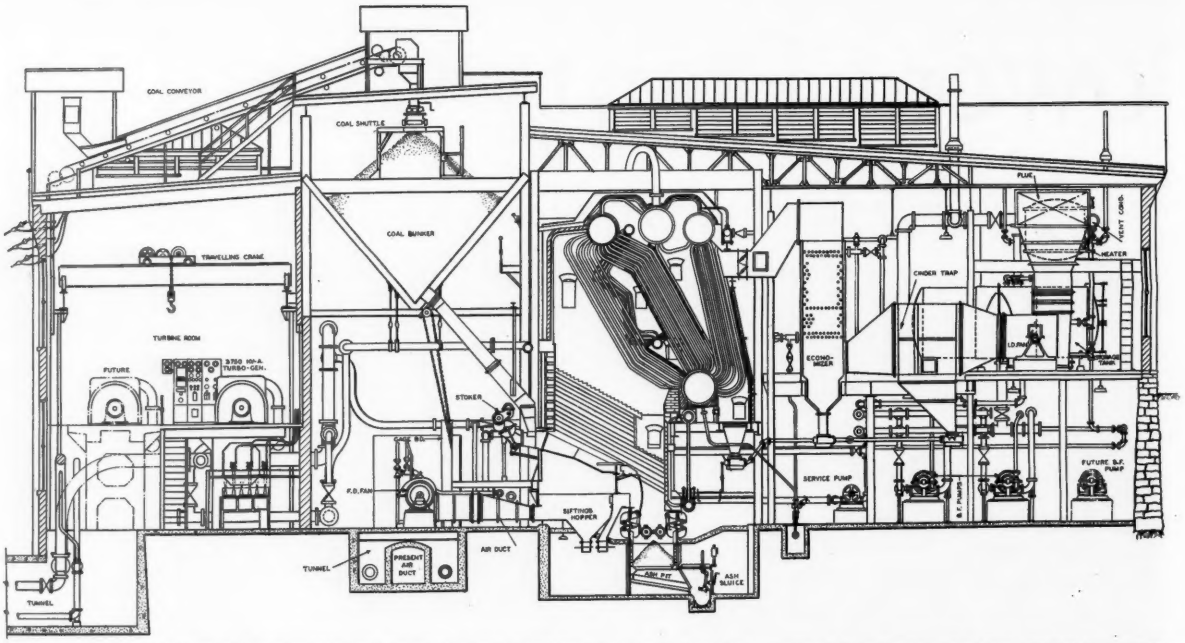


FIG. 4. GENERAL CROSS-SECTION THROUGH REMODELED POWER PLANT. STEAM PIPING LEADS DIRECT FROM TURBINE ROOM TO MILL. NO CHANGES WERE MADE IN WALLS OR ROOF OF EXISTING BUILDING

(c) two condensing steam turbine generators totalling 2000-kw. capacity as a steam standby to the purchased power connection and to the mill hydroelectric plant and generating about 7 per cent of the electricity.

Basis for Remodeling

Although the physical condition of the plants was good and the reliability of their services was without serious objection, there appeared to be heavy obsolescence as a result of the possibilities to reduce operating expenses with modern equipment properly applied to the local conditions and requirements, and especially through the generation of electricity as a by-product of process steam. Studies of the situation were made to test this opinion with the resultant conclusion that a 425-lb. pressure plant could be superimposed upon the present system with complete economic justification for its cost, provided use was made of the existing buildings and equipment adaptable to the proposed plan.

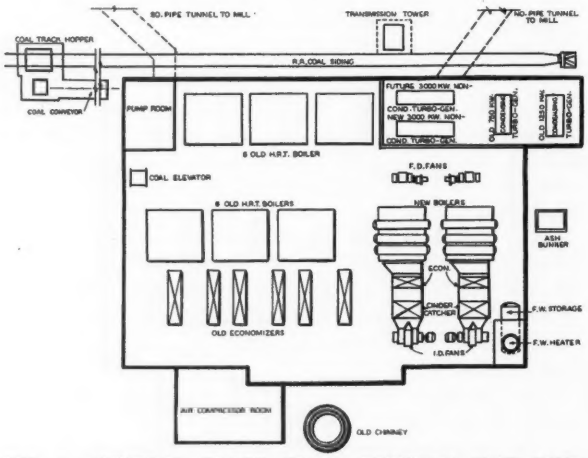


FIG. 5. GENERAL FLOOR PLAN, SHOWING HOW NEW EQUIPMENT WAS INSTALLED IN SPACE FROM WHICH OLD BOILERS WERE REMOVED

Steam generating capacity was to be concentrated in two new units and some old boilers were to be maintained for spare capacity. Use of a higher steam pressure would make a substantial amount of power available from a noncondensing steam turbine generator functioning as a reducing valve between the new steam pressure of 425 lb. and the pressure of 120 lb. required for distribution to the paper machine engines and the digesters. More power than would be required to replace the amount purchased could be produced in this manner. Amount of noncondensing power available is indicated by the graph, Fig. 3, which is a conversion of the mill steam flow curve. Average of 2000 kw. of steam power is required to supplement the average water power of 4000 kw. and carry the average mill load of 6000 kw., the variations in which are about 10 per cent. When the mill water-power output is decreased to 1750 kw. by high water, the steam power output must increase to 4350 kw. This can be easily supplied from the noncondensing and condensing turbines, using the former to the maximum and the latter to balance the load. It is expected that the total condensing power generated annually will not exceed 1,000,000 to 1,500,000 kw-hr. with the reconstructed plant containing one 3000-kw. noncondensing unit.

Operating savings and a general improvement of plant conditions were possible along the following lines to:

(1) Reduce operating and maintenance labor about 60 per cent.

(2) Eliminate the purchase of outside power, thereby making a material saving.

(3) Improve reliability of power supply and so avoid curtailing mill operations during high water periods.

(4) Correct an objectionable chimney dirt situation in the mill property and surroundings.

(5) Abandon one boiler plant building and release this space for future use in manufacturing.

(6) Establish a source from which steam and power can be furnished as required by the mill without restricting the remodeling or improvement of mill machinery and processes with limitations in the power plant.

Description of Changes

In selecting the equipment and determining its arrangement, consideration of the fullest practical use of existing properties needed to be kept constantly in mind. Figure 5 shows the general floor plan of the old boiler room building, in which the new boilers and turbine were installed. Space for the new steam generating equipment was made available by removing four old boilers and their economizers. The removal of two old boilers provided the space for the new turbine room. After these removals, twelve of the old boilers, with their economizers and auxiliaries, remained in this building and these serve as spare boiler capacity. Figure 8 is a photograph of the firing aisle for these old units.

The two new four-drum curved-tube boilers, fired with multi-retort underfeed clinker-grinder stokers and fitted with convection superheaters and extended-surface, steel-tube economizers, were installed in the northeast quarter of the boiler room. Individual forced and induced draft fans are used. A cinder trap is installed with each unit ahead of the induced draft fans, which discharge into the old 123-ft. high red brick chimney.

Future installation of additional new boilers was contemplated and planned to be in line with the present boilers after the removal of old h.r.t. units. Steam generating capacity of each unit is 120,000 lb. per hr. continuously, with a peak capacity of 150,000 lb. per hr.

Pipe tunnels, through which the steam lines to the mill run, leave the boiler room from its west side. The distribution switchboard is in the mill and to the west of the boiler plant. Accordingly, the new steam turbine

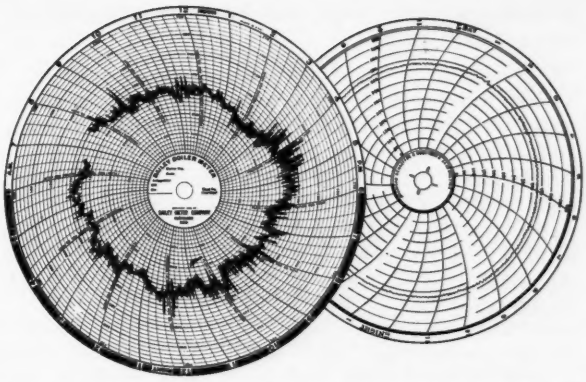


FIG. 7. CHARTS OF STEAM-FLOW-AIR-FLOW (LEFT) AND MAIN LINE PRESSURE FOR NEW PLANT

generator, a 3000-kw. 0.8 power-factor, 3-phase, 60-cycle, 600-v. machine, was installed in an extension to the present turbine room, using space made available by the removal of two old boilers. This location gives a direct travel for the steam from the new boilers through the turbine to the mill and avoids crossing the boiler room space with electric cables from the turbine generator to the mill switchboard. A portion of the generator cable run between the turbine and the mill is shown in the headpiece.

Figure 4 shows a cross section through the new boiler units and the turbine room. The installation was made without changing the walls or roof of the old building. The old V bunker was used for coal storage with no change other than an extension and the attachment of chutes to the new stoker hoppers. It was necessary to excavate in the area under the new boilers to a depth of about 8 ft. below ground, to provide the necessary height. The operating floor for the new stokers, about 5 ft. above the old operating floor, is continuous in front of and around the new boilers and connects with the old floor by short stairs at the ends of each passageway. The old economizer floor was reconstructed for the new

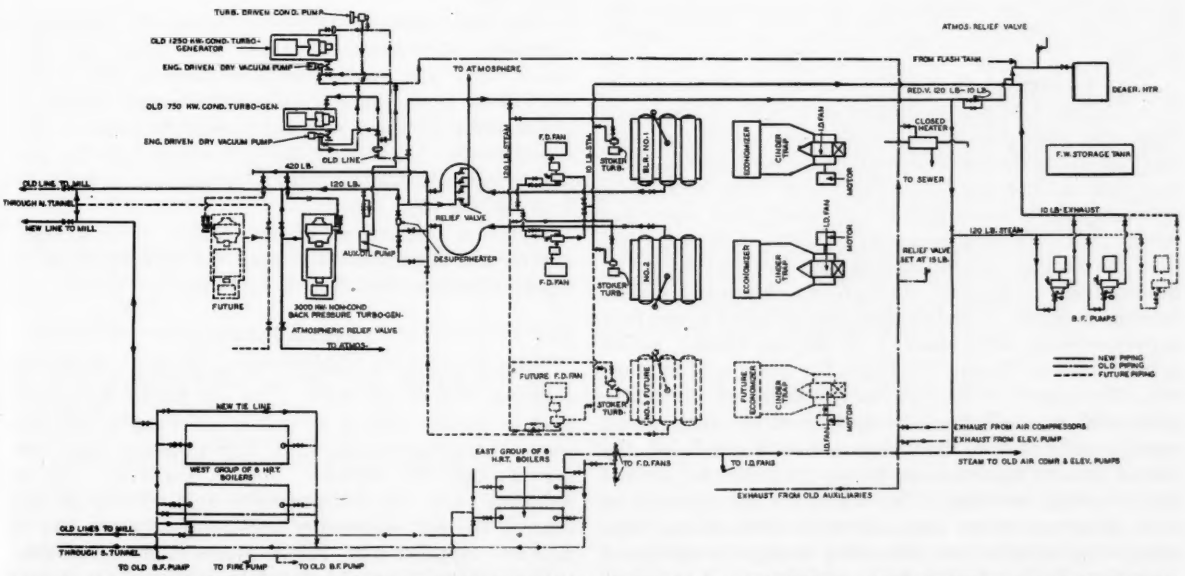


FIG. 6. LINE DIAGRAM OF STEAM-PIPING, SHOWING SIMPLE ARRANGEMENT AND METHOD OF CONNECTING NEW EQUIPMENT TO KEEP 120-LB. EXISTING SYSTEM WITH MINIMUM OF CHANGES

economizers, cinder traps, induced draft fans and feedwater storage tank.

Furnaces

The boiler settings are of refractory with sections of water wall for the bridge walls, for the side walls along and 7 ft. above the fire line, and for the front wall to within about 9 ft. of the stoker retort caps. The 9-ft. high front wall section between the retort caps and the water wall is a suspended air-cooled refractory block wall. The effective furnace volume is 3870 cu. ft. and the heat liberation at a load of 100,000 lb. an hr. is 34,000 B.t.u. per cu. ft.

Coal and Ash Handling

Ash is sluiced from the hoppers into a sump pit, just inside the northerly building wall and is pumped from

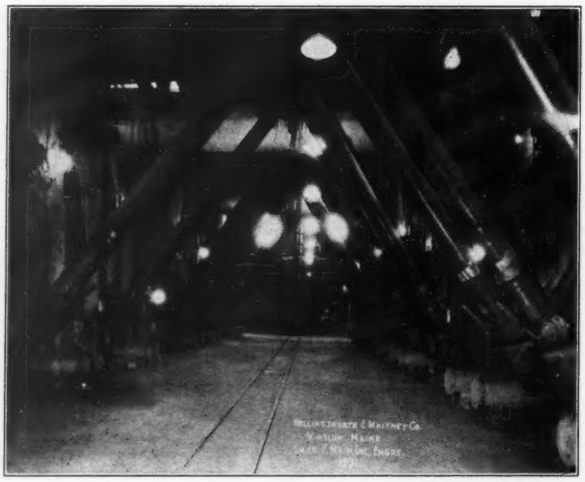


FIG. 8. FIRING AISLE FOR THE 12 OLD BOILERS THAT ARE KEPT FOR SPARE BOILER CAPACITY

this pit to a cast iron hopper outside the building. This hopper is elevated to discharge, through gates in its bottom, into motor trucks for ultimate ash disposal. Cinders are removed from the hoppers under the last boiler pass, the economizers and the cinder traps, by a hydrovactor system.

Coal is handled from railroad cars on a spur track. It is dumped into a track hopper southwest of the boiler room and passes through a crusher onto an inclined belt running along the westerly wall of the boiler room. This conveyor discharges, above the boiler room roof, to a belt carrying to the center of the boiler room above the bunker and discharging upon a shuttle belt operating over the bunker and unloading into it. Coal from the bunker feeds by gravity, through two chutes per stoker, into the hoppers. A weightometer is installed in the first conveyor room. The capacity of the old bunker, which is used without change, is enough for about a 24-hr. supply. To operate with this small storage at the boiler plant and to avoid double handling of the coal, which was the old practice, daily shipments are scheduled, the size of these being determined each afternoon for arrival the following morning. The shipments are planned so as to keep one or two full cars on the coal siding adjacent to the boiler plant, this being enough to safeguard operations against minor delays or failures. A sufficient tonnage is carried in ground storage in the upper yard to insure a continuous supply. The coal storage has been reduced as a result of this change to about one-third of its former amount.

The view of the exterior, used in the headpiece, shows the coal siding and portions of the conveyor system.

Feedwater

Deaerating feedwater heater and storage tank are installed in the northeast corner of the boiler room, with the feed pumps installed on the ground floor beneath storage tank.

Considerable heat is returned to the feedwater heater from the mill. Accordingly, the drives selected for the new boiler plant auxiliaries were steam turbines, using 120-lb. steam, for the stokers, the forced draft fans and the feed pumps; motor drives were used for the other auxiliaries.

With the feedwater system used for the old plant, no condensate was returned to the boilers. Drips in the mill were discharged through closed heaters, which were also fed with the surplus exhaust steam from the machine engines. River water, after sand filtering, was pumped through these heaters to the boiler rooms. The rate of flow was hand controlled and the endeavor was to avoid waste of exhaust steam. This arrangement prevented contaminating the boiler feed with dirty drips and provided a means of recovering some of the heat leaking from the low pressure process steam system. This arrangement was retained for the new boiler installation.

Water from the closed heaters, or heat exchangers, is delivered to the new feedwater heater. The temperature of this water, as expected, is variable, ranging normally between 160 degrees and 205 degrees F. Boiler plant and turbine drips are returned to the new heater and filtered river water under float control at the heater serves as makeup. Temperature of water leaving the feed heater is about 230 degrees F.

Feedwater treatment is controlled under license from the Hall Laboratories, soda ash and Hagan phosphate being introduced into the feed pump suction at regular intervals.

The installation provides equipment for continuous blowdown and recovery of the heat from the water blown out. The amount of blowdown is regulated in porportion to the concentration of the boiler water, the upper limit of which was determined from its relation to carry-over. Following this procedure, it is the practice to operate the blowdown system for only a few hours of the day.

Internal inspections of the heater, boilers, economizers, and superheaters showed the surfaces to be exceptionally clean and free of corrosion.

Steam Piping

Steam piping is simple, as inspection of the line diagram, Fig. 6 will show. The old 120-lb. system was kept in service with a minimum of changes and additions. This diagram shows all high-pressure steam passing through the 3000-kw. turbine generator and the reducing valve and desuperheater unit. The plant auxiliaries, the old condensing turbine generators and the mill are supplied with 120-lb. steam from the 3000-kw. turbine exhaust, supplemented by boiler steam through the reducing valve. The old boilers, if occasion requires

their use, can feed into the 120-lb. lines. Reducing valve and desuperheater unit can handle the full output of the new boilers if necessary.

The old boilers are a reliable standby; it has been demonstrated that these boilers, if required, can be brought on the line in two hours after lighting new fires.

Combustion Control

Combustion rates are controlled from header pressure by a Hagan system of control. This system, consisting of one master controller and individual controllers for stoker speed, for forced draft fan speed and furnace draft and for uptake draft and induced draft fan speed, automatically adjusts the speeds of auxiliary drives and the position of dampers to maintain good combustion conditions and handle changes in boiler load with a variation in main header pressure of 10 lb. The control can be changed from automatic to manual at will and adjustments made at the individual boiler panels located in front of each boiler. On these panels are mounted flow meters, draft gages, pyrometer recorders, CO_2 machines and station and boiler load indicators.

Charts of steam-flow, air-flow and main line pressure reproduced in Fig. 7 indicate the type of operation carried out.

This plant was reconstructed in the fall of 1930 and the winter of 1931. Dismantling of the old boilers started in August, 1930, and the new units were delivering steam in February, 1931.

Data on Proportions of Units and Plant

Ratio of economizer to boiler surface	1 to 1.3
Ratio of furnace water wall surface to boiler surface	1 to 16.8
Ratio of projected grate area to boiler surface	1 to 47
Ratio of projected grate area to furnace volume	1 to 16
Furnace volume, cubic feet	3870
Heat liberation in furnace	
(a) Maximum B.t.u. per cu. ft. per hr.	51,000
(b) Normal B.t.u. per cu. ft. per hr.	35,000
Boiler room volume per rated boiler horsepower (cubic feet)	159

Principal New Equipment in Remodeled Power Plant of Hollingsworth & Whitney Co.

BOILERS AND COMBUSTION EQUIPMENT

Boilers—Edge Moor Iron Co., 2 four-drum bent tube type, 11,210 sq. ft. each, 450 lb. maximum working pressure.

Superheaters—Foster Wheeler Corp., 2 convection type, 440 lb. and 582 deg. F.

Water Walls—Foster Wheeler Corp., 3½-in. No. 6 gage tubes. Side walls 90 sq. ft. each, armored surface. Rear wall 180 sq. ft. armored surface. Front wall and arch, 300 sq. ft. wing-back surface.

Economizers—Foster Wheeler Corp., 2 8400 sq. ft. in 2-in. diameter, 14-ft. tubes.

Stokers—American Engineering Co., two 10-retort, 29-tuyere, double roll clinker grinder. Projected area 240 sq. ft. Terry turbine drive geared.

Fans—American Blower Corp., 2 forced draft, multivane, 49,000 c.f.m each, 80 deg. F., 6-in. H_2O; 2 induced draft, multivane 104,000 c.f.m., each, 480 deg. F., 11½-in. H_2O.

BOILER AUXILIARIES

Cinder Traps—Green Fuel Economizer Co., 47.8 sq. ft. free area in 5 sections each with 8 elements.

Feedwater—Cochrane Corp., vertical cylindrical cast iron, 300.000 lb. per hr. deaerating heater and 8 ft. 6 in. diameter by 20 ft. long Armco-Iron storage tank.

Boiler Feed Pumps—Ingersoll-Rand Co., two 4-stage centrifugals, 633 g.p.m. against 1280-ft. head with 240 deg. F. water.

Ash Handling—Allen-Sherman-Hoff Co., ash hoppers, sluiceways, ash pump and Hydrovac flue dust removal equipment.

Coal Handling—Stephens-Adamson Mfg. Co., 75 t. per hour crusher and belt conveyors and Merrick weightometer.

GENERATING EQUIPMENT AND AUXILIARIES

Steam Turbine Generator—Westinghouse Electric & Mfg. Co., one 3750-kv-a., 3-phase, 60-cycle, 600-v., 3600-r.p.m. machine with 125-v. direct connected exciter.

Auxiliary Turbines—General Electric Co., two 70-hp. with Falk reduction gears, 3630 to 1400 r.p.m. for forced draft fans and two 295-hp., 2870 r.p.m. for feed pumps.

Motors—Westinghouse Electric & Mfg. Co., two 300-hp., 900-r.p.m., 600-v. slip-ring motors and motor operated drum controllers for induced draft fans.

Switchboard—Westinghouse Electric & Mfg. Co., 3 panel board for turbine generator and exciters.

Turbine Room Crane—Reading Chain & Block Corp., 15-t. hand crane, 27-ft. span.

OTHER MECHANICAL AND ELECTRICAL EQUIPMENT

Combustion Control—Hagan Corp., full automatic, controlling forced and induced draft fans, stoker turbine speed and furnace draft.

Feedwater Treatment—Hall Laboratories and Hagan Corp.

Piping—The M. W. Kellogg Co.

Steam and Water Valves—The Lunkenheimer Co.

Forged Steel Valves and Non-Return Valves—The Edward Valve & Mfg. Co.

Motor-operated Valves—The Lunkenheimer Co., Limitorque Control.

Main Reducing Valve and Desuperheater—Smoot Engineering Co.

Blowoff Valves and Water Columns—Yarnall-Waring Co.

Flue and Platework—Connery & Co., Inc.

Soot Blowers—Diamond Power Specialty Corp., on boilers, superheaters and economizers.

Boiler Settings—The Frank E. Ross Co.

Insulation—Nightingale & Childs Co.

Meters, Gages and Thermometers—Bailey Meter Co.; Brown Instrument Co.; Builders Iron Foundry; Consolidated Ashcroft-Hancock Co.; Crosby Steam Gage & Valve Co.; Foxboro Co.; Star Brass Mfg. Co.; C. J. Tagliabue Mfg. Co.

Electric Wiring—J. Livingston & Co.

Structural Steel—New England Structural Co.

Building Construction—Hollingsworth & Whitney Co.

Designing Engineers—Chas. T. Main, Inc.

Power Engineers' Day was in augurated at Penn Athletic Club, Philadelphia, on Saturday, April 2, under the auspices of the local bodies of the N. A. P. E. and other Philadelphia engineering organizations.

The program consisted of morning and afternoon technical sessions, buffet luncheon, dinner, entertainment and dance. At the sessions, papers were read by the following: Herbert A. Russell, Supt. of Power at University of Penna., Operation of Power Plants; Leo J. Burke of Burke Boiler Repair Co., Care and Management of Boilers; W. R. Goodwin, Building Supt. of Fox Theatre Properties, Maintenance and Management of Buildings; Walter C. Edge of P. B. Huyette Co., Combustion; John M. Lukens, Chief of City Bureau of Boiler Inspection, Electric Welded Boilers; Fred Kauffmann, Consulting Engineer, Practical Repairs; J. E. Simons of Electro Dynamic Co., Electric Motors as Applied to Special Applications in Industry.

The affair was well attended throughout and it is planned to make it an annual event.

Report for 1931 of The Engineering Foundation, the Research Department of United Engineering Trustees, Inc., 29 West 39th St., New York City, has just been issued. This includes results of studies of the industrial system, engineering education, Stephenson Creek experimental arch dam, concrete, steel columns, earths and foundations, researches in metals, arc welding with pure iron and other subjects. Complete financial statement is included, together with general data on the society.

POWER PLANT ENGINEERING May 1 1932

REHEAT—
Practice, Operation and Control

METHODS USED FOR REHEAT STEAM TEMPERATURE REGULATION TO GIVE CONSTANT STEAM TEMPERATURE WITH ADEQUATE PROTECTION TO REHEATER COILS, PIPING AND TURBINE

REHEAT, while adding appreciably to the thermal efficiency of a steam station, introduces new problems of temperature control and regulation. In the main these center about the desirability of maintaining constant reheat temperature at all loads and protecting the reheater coils, piping and turbine against excessive temperatures.

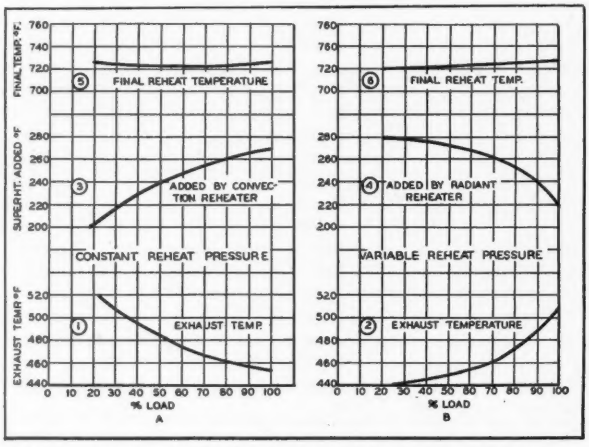


FIG. 1. TAKING ADVANTAGE OF REHEATER CHARACTERISTICS TO GIVE REHEAT TEMPERATURE REGULATION (A) CONVECTION REHEATER AS USED WITH TURBINE EXHAUST AT CONSTANT PRESSURE AND (B) RADIANT REHEATER AS USED WITH TURBINE EXHAUSTING AT VARIABLE PRESSURE

Almost a score of reheat stations[1] have been built in this country and as might be expected the temperature control equipment varies with the arrangement and design of the major equipment of the station. Some stations use gas-to-steam reheaters, some use steam-to-steam reheaters and some use combinations of the two. In some stations the high pressure turbines exhaust at constant back pressure, in others at a pressure which varies with the load. These differences influence the application of temperature control equipment.

SEPARATE REHEAT BOILERS

Early reheat stations, of which Crawford is an example, used several standard boilers to supply high pressure steam and employed a separate reheat boiler for reheating the high pressure turbine exhaust at reheat or crossover pressure. Reheat temperature is controlled by the rate of firing of the reheat boiler. Increasing boiler sizes made it possible to decrease the number of boilers to one each per turbine unit. Deepwater (N. J.) is the latest station to use this method of control.

STEAM REHEATERS

Later the steam reheater, in which the low pressure steam is reheated to the saturation temperature of the high pressure steam was introduced at Crawford and later used at State Line, Concepcion and River Rouge. Heaters located at the turbine simplify piping considerably but steam reheaters have the obvious disadvantage of limiting the available reheat to about 550 deg. F. with 1400 lb. boilers.

Against the simplicity of this arrangement must be balanced the loss of practically 200 deg. F. in reheat temperature, roughly a kilowatt for every 40 lb. of steam flow. At Deepwater (Tex.) this was obviated by using an initial superheat of 820 deg. F. and two steam reheaters in series. In the thoroughfare heater the high pressure superheat is reduced from 820 to 715 deg. F. and the low pressure steam superheated from 560 to 710 deg. F. The other heater is the regular dead end type in which the reheat steam is heated to 560 deg. F.

Introduction of the Calumet boiler with its adaptability to reheat conditions, increase of boiler sizes, the trend toward single boiler and single turbine units and the advantage of higher reheat have perhaps accelerated the tendency to equip each boiler unit with gas reheat elements, as was done with the original reheat installations at Edgar and Lakeside.[2]

South Amboy, Gilbert and Port Washington are recent examples of plants in which all boilers have reheat elements. Three methods have been used to give reheat temperature regulation: movable baffles in the reheat section; properly combining the superheater and turbine exhaust temperature characteristics; the use of steam and gas reheaters in series. Edgar is an example of the first, Lakeside and Port Washington of the second and South Amboy and Gilbert of the third method.

MOVABLE BAFFLES

At Edgar movable baffles are used to control the gas flow over the reheat coils. High pressure was superimposed on a medium pressure station and the high pressure turbine exhausts at constant pressure. The temperature of the exhaust increases at light loads as indicated by curve 1, Fig. 1. Desuperheaters, installed in the reheat steam lines leading to the reheat coils, are used when turbine exhaust temperature reaches a value which would give excessive temperature at the reheat outlet. Installed in this location, the desuperheater protects both reheater and low pressure turbine. These desuperheaters are used only when correction is

[1] See Power Plant Engineering Aug. 15, 1931 page 840 for list of reheat stations with data and reference articles.

[2] See A. S. M. E. paper Radiant Superheater Developments presented by M. K. Drewry at Hartford June 1931 and abstracted in Power Plant Engineering page 128, Feb. 1, 1932.

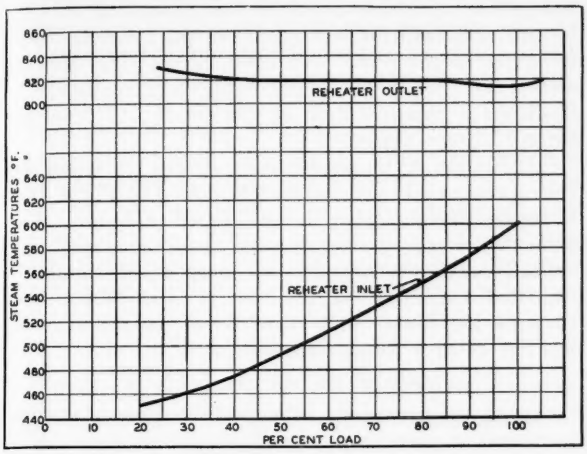


FIG. 2. CONTROLLING THE REHEAT TEMPERATURE BY PROPER APPLICATION OF REHEATERS. COMBINATION OF EQUIPMENT OF FIG. 1 B. TO PORT WASHINGTON STATION

needed beyond that given by the operation of the movable damper. A bypass is also provided, the arrangement being about the same as that shown by Fig. 6 with the desuperheater moved from the bypass to the low pressure main leading to the reheater.

Radiant Reheaters

Lakeside has solved the problem of temperature regulation by taking advantage of the different characteristics of radiant and convection reheaters and applying them correctively to meet turbine exhaust conditions. A convection reheater gives a superheat lower at light than at full load as shown by curve 3, Fig. 1, while a radiant reheater gives a superheat higher at light than at full load as shown by curve 4, Fig. 1.

These characteristics can be combined to give almost constant reheat temperature over the entire range as shown by curves 5 and 6 of the same figure. This has been done at Lakeside with constant pressure exhaust turbines and convection reheaters and will also be done at the new Port Washington station with variable reheat pressure and a radiant reheater to give almost constant temperature conditions as shown by Fig. 2.

Combination Steam and Gas Reheaters

In spite of its obvious advantages in simplifying reheat control problems, the radiant reheater has not been widely used. The convection heater as used recently at South Amboy, Gilbert and Station A has been the most popular, the reheater being designed to produce the desired reheat temperature at or near full load. Because of the characteristic (curve 3, Fig. 1) a drop in load results in lower reheat temperature. To increase the temperature at low load, a live steam heater is added in series with the gas section. Exhaust steam from the high pressure turbine passes first through the steam heater and then through the gas heater, the temperature rise allowed in the steam section being controlled by the final reheat temperature.

With one boiler per unit, as at South Amboy, the temperature control is relatively simple, involving a thermostatically controlled valve in the high pressure steam line leading to the steam heater. At Gilbert there are two boilers per turbine, each with convection reheat coils so that, in addition to the steam control mentioned above, it is necessary to proportion the steam flow to the two boilers in proportion to their rates of firing.

Details of this interesting control at Gilbert are shown by Fig. 3. High pressure steam expanded through the high pressure turbine, exhausted at from 115 to 440 lb., is split between the two boiler units, passing first through the steam and then through the gas reheat sections after which the two lines join at the line to the low pressure turbine.

Control is in two steps. Steam is divided between the units by the control drive 31 actuated by the differential temperature contactor 30. Control valves are built so that when both valves are half open they pass full capacity. Distribution is obtained by throttling one valve and opening the other. In the motor drive the ¼ hp. motor runs continuously and solenoid clutches are engaged to operate the drive sprocket as conditions require, the differential temperature contactor operating the control so as to maintain the same temperature rise from both sides.

Final Temperature Actuates Mechanism

If the steam temperature at the exit of the gas reheater drops below the desired minimum, temperature contactors 32, at the exit of the gas reheat section, actuate the control drives 33, admitting high pressure steam into the steam reheaters until the combined effect of both the steam and gas sections gives the desired temperature. This latter equipment, that is one half of Fig. 3 exclusive of valves B, C and D and elements 30 and 31, is the same as that used to divide the temperature rise between the steam and gas sections in a single boiler unit as at South Amboy.

With this series heater arrangement the gas heater, though incapable of doing the whole job, is relieved of some work by the gas section and the reheat temperature is maintained at about the full load figure until the load drops to about ¼ or ⅓ rating. At Station A the steam reheater is cut out completely at loads in excess of 35,000 kw. (about 60 per cent). Beyond this point the reheat temperature is controlled by varying the proportion of high pressure steam between the standard and reheat boilers, an additional element of control not available at South Amboy where all the

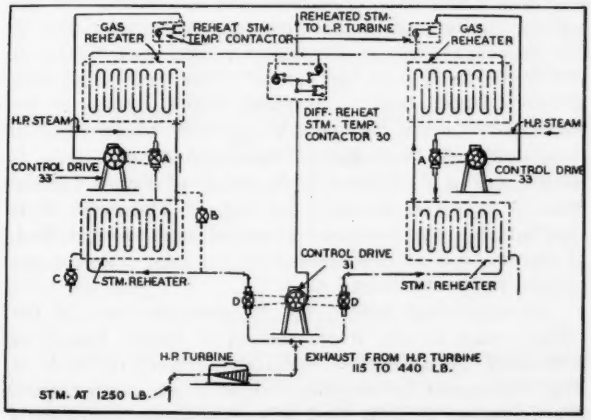


FIG. 3. DIAGRAMMATIC ARRANGEMENT OF THE REHEAT CONTROL AND PROPORTIONING EQUIPMENT AT GILBERT STATION

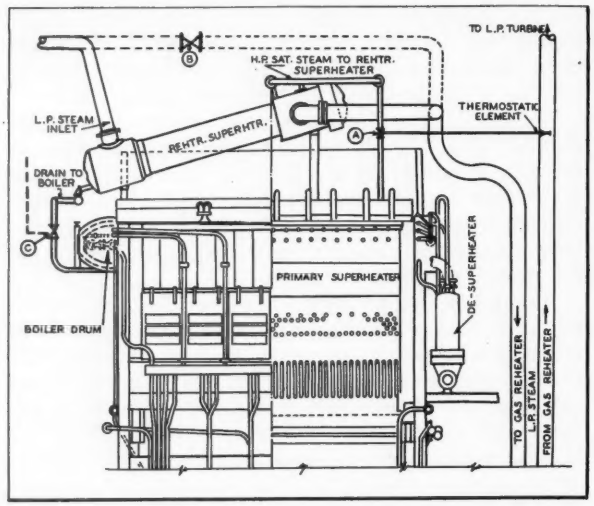


FIG. 4. STEAM REHEATER INSTALLED DIRECTLY OVER THE BOILER DRUM AS AT SOUTH AMBOY. VALVES A, B AND C ARE THE SAME AS IN FIG. 3

boilers have reheat sections and where the steam section is not cut out until about maximum boiler rating. Both Station A and South Amboy were designed as variable load stations.

Location of the steam reheater directly over the boiler drum as shown by Fig. 4, the South Amboy boiler, offers certain advantages. Piping is simplified, drain pumps are eliminated, there is no degradation of heat head of the condensate and saturated steam can be used for the heating medium.

Regulation of Temperature Rise

It is evident that with a heater of this type the reheat steam temperature can be regulated in three ways, all of which are in actual use in different plants. A valve can be installed at A to limit the flow of high pressure steam to the heater as is done at South Amboy; a valve can be installed at B so some of the steam can be bypassed around the heater as at Station A; a valve can be installed at C to control the water level in the heater and give a variable heater surface as is done at Ilse[3] (on a slightly different type of heater).

Control valves at any of the three locations can be made subject to automatic or thermostatic control from the temperature of the reheated steam leaving the gas section on its way to the turbine as shown by Fig. 3. The temperature rise through the gas sections is, of course, a function of the rate of firing and is not subjected to direct control, although baffles, bypass or desuperheater could be used if desired, under limited conditions. A thermostatic regulator of one type is shown in Fig. 3. Valves A, B and C of Fig. 4 are the same as valves A, B and C of Fig. 3. The drive 33 is shown in but one position but would have to be shifted, of course, to B or C if these were used for temperature control purposes instead of A.

As mentioned above, the temperature rise of the reheat steam in the steam section at South Amboy is controlled by a thermostatically operated valve A of Fig. 4 actuated by the final reheat steam temperature. For instance, at light load when the steam reheater is working at its maximum, the steam regulating valve A is wide open and the water level in the reheater would be down in the lower left hand corner, the distance above the level in the boiler drum being sufficient to balance the pressure drop in the steam line from the drum to the reheater.

At Station A, the temperature rise in the steam section is controlled by the bypass B, dotted in Fig. 4 (this is not the Station A boiler) and dotted in Fig. 3. With saturated steam as the heating medium, there is a definite maximum temperature limit which cannot be exceeded regardless of the low pressure steam flow through the heater and there is no danger of overheating as in a flue gas heater.

Steam Heater Drainage

If the steam reheater is not over the boiler, there is the additional problem of condensate drainage. This does not differ greatly from extraction heater practice although the larger quantities involved at the higher pressures and temperatures encountered increase the necessity for careful design.

Water level control of the heaters within a maximum and minimum value is advisable for two reasons: to keep them free from condensate so as to have full heating effect and to form a seal to prevent the bypass or short circuit of steam to a lower part of the system to which they are drained. A recent installation of this kind at the River Rouge plant is shown by Fig. 5. The condensate tank serves as a seal and surge tank, in which the level is controlled by an oil-operated flow regulating valve actuated by an automatic water level controller.

This condensate, at practically full boiler pressure, is at saturation temperature and to maintain the full

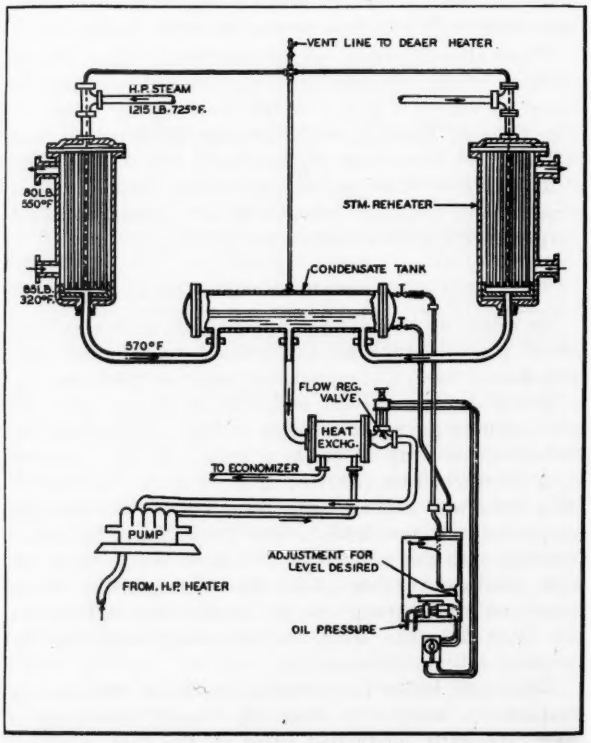


FIG. 5. STEAM REHEATER DRAINAGE SYSTEM AS USED AT RIVER ROUGE

[3]German Industrial Plant for 1700 lb. pressure see Power Plant Engineering p. 1058, Nov. 1, 1931.

heat value without the use of a separate pump it is returned to the system near the discharge of the primary boiler feed pump. The heat exchanger, supplied with water from the discharge of the boiler feed pump, cools the drains sufficiently to obviate the possibility of flashing in the pump. Vent lines go to the deaerating heater operated at 28 lb. pressure. (Note that the vent lines extend to the bottom of the heaters.) Water level in the tank is shown by a recording instrument and this level can be changed as desired by the operator either momentarily, by manual operation, or permanently by an adjustment on the level control instrument.

Boiler Protection

Protection of the gas reheat coils against excessive temperatures depends upon the equipment arrangement. With convection reheaters, as for instance at Crawford and South Amboy, this is done by opening air admission

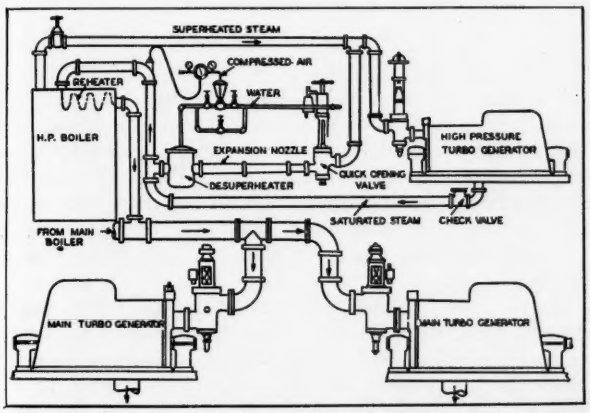


FIG. 6. BYPASS AND DESUPERHEATER ARRANGEMENT AT LAKESIDE

doors in the furnace wall. In case of sudden loss of load the boilers (reheat and standard if used) are shut down, doors opened and cold air admitted to the reheat section in order to dilute and cool the gases of combustion to a safe temperature.

These doors can be opened by manual or automatic control. Push button control is more common but automatic control has been used at South Amboy. At Statin A, with gas and oil firing, the reheat section of the boiler has no more protection than the primary superheater, the fuel supply being cut off by push button control from the fireman's panel.

Although opening air doors can be used to protect convection reheat coils, this method is not entirely practical for radiant reheaters as used at Lakeside. There a bypass and desuperheater arrangement is used, as shown diagrammatically by Fig. 6. In case the high pressure throttle is tripped, the high pressure steam is bypassed through the quick acting valve, expansion nozzle and desuperheater to the low pressure line leading to the reheater.

Turbine Protection

In protecting the reheat coils against excessive temperatures, the question of protecting valves, piping and other equipment against excessive temperature is taken care of automatically. Additional turbine protection is necessary, however, to prevent overspeeding of either element. In a station where the high pressure equipment is superimposed on the low pressure station, with a constant reheat pressure, the low pressure turbine governor takes care of this.

In cross compound units it has been common to provide both elements with operating and overspeed governor control so that the low pressure element can be used separately if necessary. Under normal conditions the elements are connected together electrically and operate as a single unit. If for some reason the disconnects between the two generators open and load is lost on the low pressure element, the low pressure governor operates to prevent overspeeding. Excessive cross-over pressure is prevented by a relief valve following the gas reheater.

Further equipment is necessary to prevent overspeeding of the low pressure turbine by steam in the reheater and piping but not under governor control. This overspeeding may be caused by the low pressure turbine losing the load or by a sudden and considerable decrease in load. This is taken care of by an interceptor valve placed as close to the low pressure turbine as possible. It is in the nature of a low pressure throttle valve under control of the low pressure governor in the case of a cross compound or the main overspeed governor in the case of a tandem compound. Usually this steam is taken by a bypass to the condenser, entering through a diffuser which distributes it over a large surface.

New Sodium Vapor Lamp Has High Efficiency

Considerable interest is being accorded the new hot cathode radium vapor lamp developed in Germany by Dr. M. Pirani, Director of Research, the Osram Co. in Berlin. This lamp is the most efficient light source yet developed. It has an efficiency of 70 per cent which is three to four times as efficient as the neon lamp and it gives six times as much light for the same current as the 40 watt tungsten lamp. The increased efficiency of the radium vapor lamp is due to the fact that practically all of the radiation from the element sodium falls very nearly in that part of the spectrum which is most sensitive to the eye. Thus 70 per cent of the electric energy passed through the vaporized sodium is converted into light. This lamp was demonstrated for the first time in this country by Dr. Harvey C. Reutschler of the Westinghouse Lamp Co. recently before the Science Forum of the New York Electrical Society.

Correction — Unbalanced Motor Currents

Mr. Johnston calls attention to the last paragraph, column 1, of the article on page 296 of April 1 issue in which the last sentence should read: If the slip (positive sequence) is s, the negative sequence slip is $200\text{-}s$ per cent.

Copper harder than most common steels has been announced. No appreciable weight is added. Electrical conductivity is reduced about 30 per cent. Accurately speaking, the product of the new process is a copper alloy.—Chemical Digest.

POWER PLANT ENGINEERING May 1 1932

Characteristics of Materials for Flange Bolts

In this Design of Power Plant Piping the Choice of Flange Bolts and Nuts Has Much to do with the Success of the Installation. By Henry C. Moffett*

STRENGTH of a flanged joint depends largely on the strength of the bolting materials used. The more severe the service, the more important the choice of bolts and nuts becomes. A great deal of trouble has been caused in the past by faulty bolts, and even now engineers are not in accord as to the best materials to use in given cases.

In order to bring more order in the practice, the American Society of Testing Materials formulated standard specifications for bolting materials in high temperature work, which was adopted in 1927. This has been accepted as a guide by most of the engineers, and when specifications refer to them, all manufacturers follow the rules laid down. This has been a great help in many ways and has raised the standard of materials used, which in turn has eliminated many of the troubles formerly encountered.

Location of Bolt Holes

All pipe flanges are drilled for bolts in multiples of four holes, except some special flanges, which have only two holes. All flanges not loose on the pipe, are drilled with holes straddling center-lines, so that the flanges may be turned in any quarter. In the past, many flanges were drilled with ten holes or some other number of holes not multiples of four, but this is now all standardized in published bulletins of the American Standards Association.

Bolt holes on all cast fittings and cast flanges should be spot-faced on the back of the flanges, so that the bolt nuts may have even bearing surfaces when drawn up. On low pressure water lines, or other low temperature piping, this is frequently omitted, as the bolts do not have to be pulled up as tight, hence uneven pulls on the screw threads of the bolts and nuts make little difference. On the larger sizes, however, this is not the case, as it is necessary to equalize the pull around the entire bolt circle.

Strength of all the bolts in any flanged joint should equal the internal pressure acting on an area the diameter of which corresponds to the outside diameter of the gasket bearing surface, plus a margin for outside forces acting on the joint. These outside forces may be due to the expansion of the pipe line, or to the weight of the valves and specialties, which are often quite heavy. Most of the strains due to the weights of these parts should be relieved by the proper hanging of the pipe lines; the proper use of bends or expansion joints should take care of most of the expansion strains. Bolts, however, are designed using large safety factors, since there are always many unknown or indeterminate strains which exist.

Physical Properties of Bolts

On low pressure lines, up to 175 lb. per sq. in., where temperatures do not exceed 400 to 500 deg. F., bolts are usually carbon steel, preferably mild, made by the open-hearth or Bessemer process. Those obtainable on the market are made with square heads, forged by upsetting. The steel from which these are made should be clean, that is, free from included slag or dirt, otherwise bolts made from poor rods may snap off in service. Inferior steel will also stretch unduly and cause leaky joints.

Since steel stressed beyond its elastic limit may take a permanent set, bolt steel should have physical properties which will allow tightening without much stretching, especially on lines carrying steam. If a flanged joint on such a line is allowed to cool and the flanges contract, the bolts should contract a like amount; but if the bolts are stretched beyond the point of elasticity, they will not come back to their original length and leaks will occur. Repeated tightenings will not keep such joints tight.

On lines carrying steam above 250 lb. per sq. in., or on lines where large changes of temperature occur, ordinary screw stock or wrought iron should never be used for bolting materials, for such bolts will not have the properties necessary to keep joints tight in service. For high temperature work, heat treated alloy steel studs should be used, with nuts on each end. Details of these are given in the Standard Specifications, A. S. T. M. Designation: A-96-27. For satisfactory results, on lines carrying steam or other fluids at 750 deg. F., bolting materials with great tensile strengths and elastic limits should be always specified.

Alloy Steels Available

There are several different alloy steels that may be used for bolting materials for high temperature service, such as chrome-nickel, chrome-vanadium and chrome-manganese. Each of these has characteristics which make them suitable for this work; the choice often resolves itself into the question of price, or personal preference. Many manufacturers offer such bolts and will furnish customers or engineers with all the physical and chemical data relating to their particular products, on request.

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The standards divide all alloy steel bolts into three classes, according to their physical characteristics, namely:

Class	Tensile Strength lb. per sq. in.	Yield Point lb. per sq. in.	Elongation in 2 inches per cent	Reduction of Area per cent
A	95,000	70,000	20	50
B	105,000	80,000	20	50
C	125,000	105,000	16	50

Bolt sizes, the number of bolts per joint, and bolt circle diameters have been standardized in tables published by the American Standards Association and, if these are followed, bolt stresses will be kept within safe limits, with ample factors of safety. The allowable fiber stresses are kept low, for even heat treated alloy steels should not be stressed beyond safe limits, and repeated stresses beyond certain points may result in increases in length or other changes of shape.

Repeated alternations of applied force, due to expansion and contraction, even if not beyond the elastic limits, may finally cause bolts to break, regardless of the ductility of the metal. Furthermore, internal strains are also set up, due to changes of temperature, which if repeated often enough, contribute to the ultimate failure of the bolts. It is important, therefore, that the bolts be large enough and strong enough for the service for which they are intended.

Class A bolts are intended for use on lines carrying pressures of 250 lb. per sq. in. up to 400 lb. per sq. in. The extreme temperature is specified as 750 deg. F. Class B bolts are for lines carrying pressures between 400 lb. and 600 lb. per sq. in. Class C bolts are for work between 600 lb. and 1350 lb. per sq. in. Higher pressures are allowed for non-shock practice, details of which may be referred to in the Tentative American Standard A. S. A. B. 16e-1927.

Hardness of the finished steel is also an important factor, hence the standards indicate that each should have a certain range according to the Brinnell test: Class A: 190 to 250; Class B: 210 to 270; Class C: 260 to 320.

Effects of Sulphur and Phosphorus Content

Standard specifications also limit the sulphur and phosphorus content of alloy steels as follows:

Sulphur, not over .....0.05 per cent
Phosphorus, not over .....0.045 " "

Materials higher in sulphur and phosphorus are not recommended and their percentages are definitely limited by the accepted standards published by the American Society of Testing Materials.

Sulphur is always dangerous in greater quantities, because of its ability readily to combine with iron and manganese. When these combinations are present, the steels are inherently weak, as these combinations have little strength in themselves, and have a peculiar ability to form on crystal boundaries. Excess sulphur also causes shrinkage of the metal on cooling, resulting in cracks. This is because the sulphur has a tendency to segregate.

Phosphorus and its compounds with iron act in much the same way, except that they will appear in streaks. This is also due to the tendency to segregate. These streaks are especially treacherous when steels are subjected to repeated stresses, as the phosphoric bands are weak.

Bolting materials, when rolled from ingots, should be closely inspected at the mill. Unless the ingots are properly cropped, the resulting rods may contain pipes, seams or dirt. These impurities are hard to detect, as they may not show from the outside of the rods. Close inspection, however, should remove all rods of this kind, before they are cut and threaded for bolts or studs, for unless they are removed, such materials may break in service. Failures of this kind are due to the reduced sections of good metal, and to the internal stresses set up during heat treatment.

Results of Heat Treating Alloy Steels

Heat treatment of alloy steels, when properly carried out, gives them improved physical properties. Constant inspection is necessary to insure that such properties are being obtained. After heat treatment, test bars should be cut for each heat, and these tested for tensile strength, hardness, reduction of area, resistance to shock and elongation. Some manufacturers have other tests that they apply, such as high temperature tests and torsional tests. These are all valuable and assist in the production of a uniformly high-grade product.

Chrome-manganese alloy steels, suitable for making high temperature bolts, have carbon content around 0.45 per cent. These have proven satisfactory, as they have a quality referred to as "tough hardness". One of these on the market, without heat treatment, has a tensile strength of 100,000 lb. per sq. in. or more, and an elastic limit of 60,000 lb. per sq. in. Oil tempering greatly increases both of these physical properties without any great sacrifice of toughness, and the resulting steel up-sets and machines without trouble.

There is also produced a chrome-nickel steel, suitable for bolting materials, which has a carbon content of from 0.25 to 0.35 per cent, which after heat treatment and normalizing has a tensile strength of 130,000 lb. per sq. in., and a yield point of 110,000 lb. per sq. in. This steel has between 1.4 and 1.8 per cent of nickel, and corresponds to the S. A. E. (Society of Automotive Engineers) Specification No. 3130.

Another alloy steel produced in late years contains chromium, manganese and tungsten. This product holds great promise for use on extremely high temperature lines, since it has physical properties, after heat treatment, which hold up remarkably well at temperatures above 750 deg. F. This material has been used both in cast and rolled form in oil refinery practice, for valves and fittings up to 1100 deg. F., with success. The manganese content ranges below 0.5 per cent; the chromium between 5.0 and 6.0 per cent, and the tungsten slightly under 1.0 per cent.

Consideration of Nuts Is Essential

Nuts used on bolts and studs in bolting practice should be given fully as much consideration as the bolts, since the strength of a joint is dependent on them as well. Frequently leaks in flanged joints have been traced to the use of inferior nuts.

Nuts are made either hot pressed or cold punched, hexagonal or square. Some are known as U. S. Standard,

others are known as Manufacturers Standard. Case-hardening is specified by some engineers, others specify heat treatment. In all cases nuts are trimmed and chamfered, usually specified as semi-finished.

On low pressure lines it is usual to specify cold punched nuts, U. S. Standard, one nut per bolt up to and including 1½ in. size. Sizes larger than this require studs with nuts on each end. If the lines are low temperature, the nuts may be commercial, that is, made from ordinary screw stock or wrought iron.

Flanges on steam lines, or other lines where large temperature differences may take place, should be fitted with better bolting materials, and especially better nuts. Case-hardening, in some instances has proven satisfactory. Caution should be exercised, however, as some case-hardening is not more than skin deep, and this is likely to make the threads brittle. Such threads may shear or break off, causing joints to become loose and leaks to occur.

Nuts for use in high temperature service are mentioned in the Standard Specification, A. S. T. M. Designation A 96-27 as falling in two classes, according to their sulphur and phosphorus contents and it is contended by some engineers that if the content for sulphur is kept below, or does not exceed 0.15 per cent, and the phosphorus is kept below or does not exceed 0.05 per cent, the nuts will be satisfactory for such service. It has been the contention of others, however, that all nuts on high temperature lines should have a sulphur and phosphorus content both below 0.05 per cent, and the carbon should not exceed 0.45 per cent or fall below 0.30 per cent, and that the nuts should be heat treated the same as the bolts.

Cold punched nuts with alloy steel studs are not recommended, as the nuts are apt to crystallize or change shape at elevated temperatures, hence stick. Such nuts, when once stuck tight are practically worthless, as it is usually necessary to break them to loosen them up.

Opinions greatly differ regarding the proper nuts to use for any given service but it is becoming apparent to most users that the nut should be as good as the bolt or stud in all cases.

Combustion in Pulverized Fuel Furnaces

INVESTIGATIONS CARRIED ON WITH TWO TYPES OF FURNACES SHOW PROGRESS AND RATE OF COMBUSTION UNDER DIFFERENT CONDITIONS. BY E. H. TENNEY*

STREAM LINE FIRING of pulverized coal is characterized by delayed admission of secondary air while the turbulent type is characterized by all air being mixed with the coal before admission. These two types of firing are widely used and embrace most of the features found in the majority of large stationary boiler installations using pulverized coal.

It must be stressed, however, that these installation studies were originally designed to meet certain space and economic limitations for low grade, Central Illinois coal and to that extent the conclusions reached cannot be applied generally to other horizontally and vertically fired installations where fuel or economic conditions differ. At the same time, the results should serve as an indication of what may be expected when using other grades of fuel.

In order to bring out the differences between these methods of firing and thereby permit of the application of both theoretical and practical considerations to their explanation, a series of parallel investigations were made, one on a furnace fired by the stream line method and the other on a furnace, identical in all essential respects, fired by circular turbulent burners. Both furnaces were fired with medium grade midwest bituminous coal, which has a heat value of 10,650 B.t.u. per lb., contains 13 per cent ash with a fusing temperature of 1980 deg. F. These furnaces are located in the same plant, receive their coal from the same storage bin system and all observations were taken with the same operating conditions prevailing throughout each furnace, thereby establishing a common basis for comparison.

Stream line fired furnace is illustrated at the left of Fig. 1. About 15 per cent of the air required for combustion is admitted at 12-in. water pressure through ten vertical burners of the fan tail type with riffles added to the burner tip to break up the coal stream. The remaining 85 per cent of combustion air is admitted through ports in the front wall which induce air, by furnace draft, from hollow lanes in the side walls. The rise in temperature of the air passing through these lanes is 20 deg. F. A horizontal hearth screen of water tubes assists in reducing slag formation in the pit. Side and rear walls are cooled with bare, vertical water tubes set between projecting courses of refractory.

Turbulent method of firing is shown at the right of Fig. 1. Through four circular burners, about 50 per cent of the primary air is admitted with the coal through a 10-in. pipe. Immediately surrounding this central pipe is a housing admitting the remaining 50 per cent of the air, mixing it with the coal stream with a circular motion controlled by adjustable vanes. Another adjustable vaned deflector on the end of the coal pipe deflects the coal stream into the surrounding air stream setting up a centrifugal turbulence. There is no hearth screen. A water-cooled, bare-iron floor is part of the side water wall system. The side and rear walls are the same as in the vertically fired boiler. Both boilers have a heating surface of 18,010 sq. ft. and 4070 sq. ft. superheaters. The stream line furnace has in addition 2093 sq. ft. of side wall, rear wall and slag screen water-cooled surface and 13,000 cu. ft. of furnace volume above the slag screen. The other furnace has 3422 sq. ft. of front, side, rear wall and ash pit cooling surface and a furnace volume of 13,275 cu. ft.

COMBUSTION PROCESS

The process of combustion through each of the two furnace installations, was studied at four and five boiler ratings. By means of water-cooled sampling tubes, Orsat analyses were taken at a number of points in a plane

*Chief Engineer of Power Plants, Union Electric Light & Power Co., St. Louis, Mo. From a paper presented before the Third International Conference on Bituminous Coal, Pittsburgh, Pa.

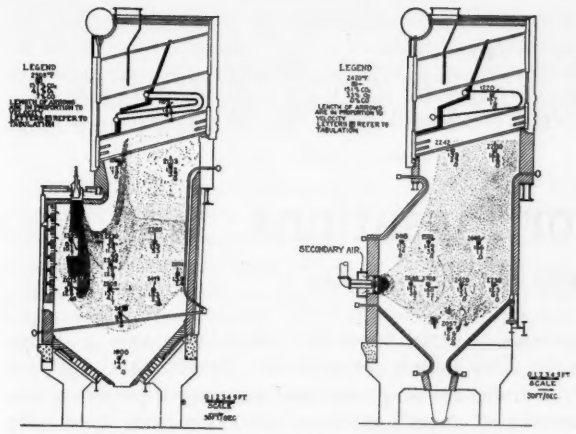


FIG. 1. COMBUSTION CONDITIONS AT 250 PER CENT BOILER RATING. STREAM LINE FIRING AT LEFT, TURBULENT FIRING AT RIGHT

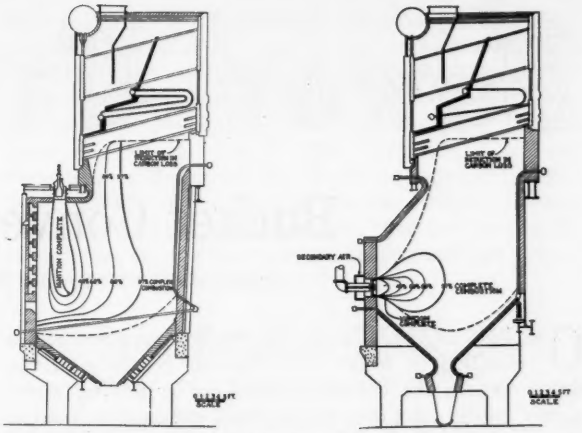


FIG. 2. IGNITION ZONE AND ISO-COMBUSTION LINES FOR FIG. 1

5.5 ft. from a side wall (which is in the heart of the flame). With water-cooled pitot tubes and thermocouples, gas velocities and temperatures were also taken. Dust samples for carbon determinations were taken for two comparative ratings through water-cooled tubes to alundum porous filters. Careful attention was given to all air, coal and draft adjustments by the regular furnace operators to establish conditions exactly as several years of operating experience have indicated to be those commercially most economical. The results of these explorations are shown in Figs. 1 to 3.

Rapidity of combustion seems to be the outstanding difference between the two methods of firing. With stream line, "delayed-air-admission" firing at 250 per cent rating (15,100 B.t.u. heat liberation) combustion is complete 36 ft. from the burner tip and 13 ft. from the point of ignition, as shown by the curves of Fig. 3. Final ignition in the core of the flame requires 0.7 sec. From burner tip to complete combustion required 1.4 sec., while combustion itself requires 0.7 sec. With turbulent firing at the same rating, combustion is complete 13.5 ft. from the burner tip and 10 ft. from the point of ignition. Combustion and ignition require 0.55 sec. or combustion 0.50 sec. and ignition 0.05 sec.

Theoretical flame propagation rates suggest that

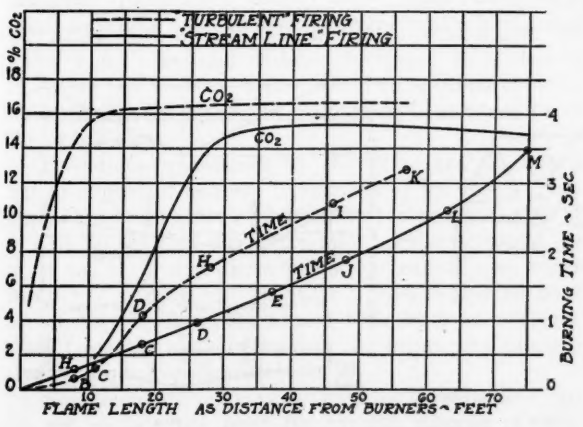


FIG. 3. BURNING TIME AND PER CENT CO_2

Stream line firing shows full CO_2 at 36 ft. from burner, burning time 1.4 sec. Turbulent firing shows full CO_2 at 13.5 ft. from burner, burning time 0.55 sec.

combustion times for the two firing methods should be relatively 1.8 to 1. Actually it is seen that the ratios of combustion times are 1.4 to 1.0. This can be considered as a fairly close agreement between theory and practice and suggests that rate of flame propagation may be taken as being proportional to combustion time.

Combustion time for stream line and for turbulent firing, respectively, should be 0.39 and 0.46 sec. theoretically, compared with 0.7 and 0.5 actual. With turbulent firing it is apparent that the speed of combustion about meets theoretical estimates. The other mode of firing falls considerably short of theoretical estimates, the ignition time in particular being very slow. This is obviously due to delayed delivery of air to the coal particles and because of inadequate mixing in the zone 18 to 36 ft. from the burner. These comparisons with theoretical estimates, must, of course, be used with considerable discretion but the reasonably close agreement substantiates the soundness of the theoretical explanations and calculations.

The question arises as to what value this more rapid combustion, attributed to burner turbulence, has if furnace volumes cannot be reduced accordingly. In order to avoid smoke and slag with the slow burning, stream line firing considerably greater excess air must be carried. This necessity for greater excess air and lower CO_2 is responsible for a difference of 1.2 per cent in operating efficiency. There are more recent installations of stream line firing, such as firing from both ends of a double boiler setting, where these conditions are largely corrected. To this extent the installation studied here is not fully representative of the best vertical firing.

AIR-CONDITIONING equipment sold in February, 1932, as reported to the Bureau of the Census by 41 identical establishments, had a total value of $701,840. Of this total, the fan group of equipment totaled $388,488, the unit heater group $246,052, and the air washer group $67,300.

AN APPRECIABLE saving can often be made in conduit work for motors and control by using armored cable installed in metal troughs or large pipes. This method of handling cables has given satisfactory results in the middle west during the past few years.

POWER PLANT ENGINEERING May 1 1932

Power Utilization

Bucket Conveyor Pulsations

CAUSE, AMOUNT AND THE REMEDY BY CHESMAN A. LEE

OCCASIONALLY, a pivoted bucket conveyor job is installed in which a rhythmical groaning of the drive occurs; the conveyor seems to be pulling alternately harder, and then not so hard, sufficient to remind the purchaser that all long-pitch chain conveyors have a slight pulsation although both the chain and drive have a factor of safety ample to provide against trouble. This article is concerned with such pulsations and how to minimize them.

CAUSE OF PULSATIONS

Usually the conveyor path is similar to Fig. 1 and causes no trouble. Sometimes the path is as in Fig. 2

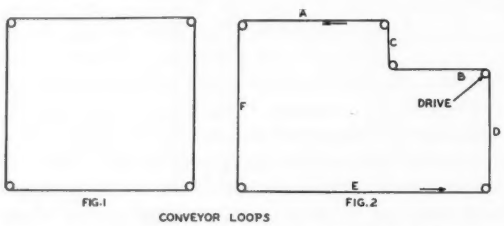


FIG. 1. PLAIN CONVEYOR LOOP

FIG. 2. LOOP WITH SIX CORNERS

or even more complicated; then careful consideration is required to avoid real trouble. The writer has seen one job with six corners as per Fig. 2 which pulled itself to pieces in three years time without once being fully loaded. The lower run, E, had a jack-rabbit motion and the drive groaned in synchronism, with the conveyor empty. It should be noted, however, that little pulsation was noticeable in the conveyor at the drive itself. The explanation given was that lost motion all along the way added up to make the effect, which was most noticeable in the lower run where the chain pull was least. This sounds plausible but doesn't stand analysis.

Careful investigation disclosed that a pulsation was introduced at each corner of the chain path. Each pair of idler sprockets generated a pulsation and these pulsations added up instead of averaging out. Application of the principles of ordinary mechanics was sufficient to predict exactly the hop-skip-and-jump so noticeable in the lower-run of this conveyor, yet slight changes in the lengths of different sections would have eliminated the trouble.

There will be absolutely no trouble, if the center-to-center distance of corner-shafts is made equal to a whole number of chain-pitches. Then the pulsation introduced at one idler cancels the pulsation already in the conveyor as it is only when the pulsations are compounded that trouble ensues.

In Fig. 2, each of distances A, B, C, and D, was an odd number of feet although the conveyor was 24 in. pitch. In other words, in each section there was an odd half-pitch. Moving the short vertical section one foot to the right (or left) would have made the job satisfactory and no trouble would have ensued. In operation there would be a slight pulsation from the drive but this would be cancelled by that introduced at the first corner. The short vertical section, C therefore, would have almost no pulsation but one would be introduced by the next corner. This, in turn, would be cancelled by that from the next corner and the long horizontal section, E, would have almost no pulsation.

The idea is that each corner introduces a pulsation but that this pulsation may either cancel one already in the conveyor or it may increase it, depending upon its phase-relationship, which phase relationship depends upon the distance between corners. The above assumes

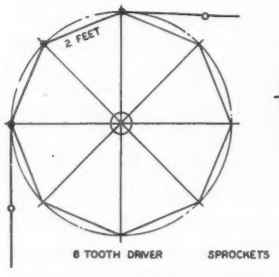


FIG. 3

FIG. 3. CHAIN ON EIGHT-TOOTH DRIVER SPROCKET

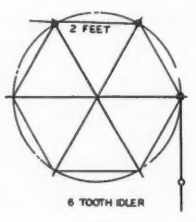


FIG. 4

FIG. 4. CHAIN ON SIX-TOOTH IDLER CUTS INSIDE PITCH CIRCLE

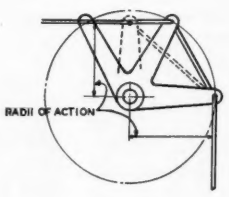


FIG. 5

FIG. 5. BELL-CRANK LEVER ACTION IS SHOWN FOR SIX-TOOTH SPROCKET

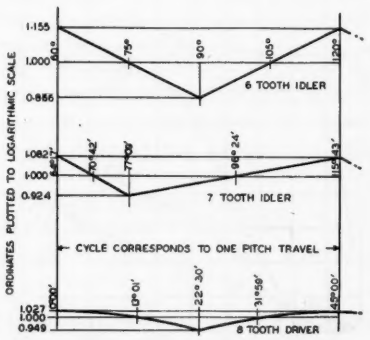


FIG. 6

FIG. 6. VARIATION OF CHAIN SPEED FOR SPROCKETS REVOLVING AT UNIFORM SPEED

that 6-tooth sprockets, or equivalent wheels, are used for idlers as is standard. If, as is sometimes done for important jobs, 8-tooth sprockets are used, no pulsations would be introduced at 90-deg. corners. This statement requires explaining.

Why Chain Speed Varies

It will be noticed, Figs. 3 and 4, that the chain fits a sprocket on a pitch-polygon rather than a pitch-circle. Although a circle may be drawn through the pitch-points, the chain cuts across this circle between the pitch-points. A little study of Fig. 4 shows that for steady chain velocity the sprocket turns alternately faster and slower as the pitch-points rise and fall in passing through the last 60 deg. before leaving the sprocket.

If the sprocket turns at uniform speed, the oncoming chain must have a varying speed and chain will leave the sprocket alternately faster and slower than it comes onto the sprocket. Of course the statement is equally true as to the chain approaching the sprocket compared to the chain leaving.

Amount of Speed Change

As a matter of fact, speed of the chain approaching the sprocket bears a ratio to speed in leaving exactly equal to the ratio of the respective radii of action at the instant considered. This is of special interest because at an idler sprocket, the speed of the chain approaching the sprocket depends upon the speed at which the sprocket is turning but the sprocket itself has a varying speed, even when leaving-speed of the chain is practically constant. Thus at an idle-corner with 6-tooth sprockets, the speed of the chain approaching alternates between 86.6 and 115.5 per cent of the leaving speed. Referred to the speed of the sprocket, the variation is between 90.7 and 104.6 per cent. Thus, if speed of the first section between drive and idler is exactly 50 ft. per min., the next section (approaching the idler sprocket) would alternate between 43.3 and 57.7 ft. per min. On the other hand, if the 6-tooth sprocket were the driver and turned at uniform speed (4.17 r.p.m. for 24 in. pitch), speeds of both approaching and leaving sections would alternate between 45.4 and 52.4 ft. per min.

Some good practical engineers have found it difficult to believe that two sections of the same conveyor could be going at different speeds at a given instant. In Fig. 5, the instantaneous motion action is that of a 90-deg. bell crank with a cable, shown dotted, passing over the ends of the arms and fastened to them. It is obvious that, for the position shown, the two sections of cable have momentary speeds in proportion to the lengths of the crank arms.

Pulsations introduced by the drive are, therefore, not so important as those introduced by the idlers. Subsequent corners introduce still further pulsations, so it is easy to see that the effect may become serious. We must see to it that these pulsations cancel each other instead of adding up. In other words, beginning with the drive, the first, third, and fifth sections, at least, should contain a whole number of pitches. An alternative is to use 8-tooth sprockets.

Equalizing drives may be used as a refinement but do not obviate the need for careful spacing of idle-corners. It is the idlers which are important.

The writer has calculated the variations in speed at 2½ deg. intervals for 6-tooth and 7-tooth idlers and for an 8-tooth driver. Expressing the speed of chain approaching an idler in terms of the leaving speed as a reference, the results plot to logarithmic scale as a series of straight lines, indicating that the accelerations are constant. For the 6-tooth idler, the graph is symmetrical. For the 7-tooth idler, however, the graph slopes steeply downward and gradually upward indicating an uneven action. In fact for the 7-tooth sprocket, the first part of the graph is steeper than for the 6-tooth. In each case the change is abrupt at high and low points. The graphs are given in Fig. 6.

Oil Specification Difficulties

By K. A. Newman*

PURCHASING MATERIALS on specifications is undoubtedly a present tendency and a step toward wiser and more scientific buying but, specifications are not a cure-all and should be used with intelligence. Specifications can never take the place of business integrity of the seller and, unfortunately, may serve as a cloak for an unscrupulous supplier.

This is true in the purchase of lubricating oils, since no specifications, however inclusive, have been able to guarantee quality because that intangible quality "oiliness or lubricating ability" cannot be embodied in specifications. If the buyer could specify the exact nature of crude from which the oil was to be refined and all the details of refining, as well as the final qualities of the oil, he might be more nearly sure of the quality of the oil bought. But then how could he tell whether all his requirements regarding the source and manufacturing process had been complied with? Therefore, I believe it wiser to rely on the integrity of the supplier for the best product for a given purpose at an economical price.

Oil specifications state the physical properties of an oil, not its lubricating ability, such specifications being usually created by analyzing some oil which has been successful on the job. The physical properties usually referred to are: 1, Viscosity; 2, flash point; 3, fire point; 4, cold test or pour test. These factors look well on a laboratory report but do not indicate the lubricating value of oil, nor do they insure satisfactory performance.

Viscosity

Viscosity merely measures resistance to flow through a certain size orifice. As temperature of the oil has a great influence on its viscosity, for the purpose of comparison viscosity readings are usually taken at a temperature of 100 deg. F. Size of orifice in the bearing to be lubricated and the temperature of the bearing seldom agree with the size of orifice and the temperature at which the viscosity was measured and two oils having the same viscosity in a laboratory test taken at 100 deg. F. may have nowhere near identical viscosities at the somewhat higher temperatures under which they may be used in the bearings.

Oils of the same viscosity made from asphalt base crude or from Pennsylvania crude, may have lubricating values differing greatly. Viscosity readings, therefore, mean little except to the experienced lubrication engineer and to the oil refiner as a check on the uniformity of his product.

*Houghton Research Staff.

Viscosity is useful as an indicator of internal friction, since a thick oil will have greater internal friction than a thin oil. Here again, it means nothing unless taken at the temperature at which the oil is to be used. Anyone can see the error of specifying oil whose viscosity is a certain amount at 100 deg. F. when it is to be used at a higher or lower temperature. Viscosity of two oils may be the same at 100 deg. F., yet nowhere near the same at 150 or 175 deg. F. Viscosity of an oil may remain fairly constant through a temperature rise of 10 or even 25 deg. and then may fall away rapidly.

Flash Test

Flash test of an oil indicates the temperature to which it must rise at a specified rate of heating so as to free enough vapor to flash, or momentarily ignite, when an open flame is passed above it. In testing oil for its flash point, the oil is gradually heated, a small flame being passed across the surface of the oil for a few seconds at each few degrees rise of temperature. When the vapor flashes, that temperature is taken as its flash point.

Fire Test

Fire test is the temperature, usually 25 to 75 deg. F. above the flash point, at which the oil gives off sufficient vapor to burn steadily when subjected to an open flame.

Flash and fire tests are usually given much prominence when oil is to be subjected to high service temperatures, yet these tests are taken at atmospheric pressure with an open flame brought into contact with the oil. While in air compressor lubrication, for example, it is customary to specify oil of high flash point under test conditions, yet the oil functions under high pressure, which automatically raises its flash point and never comes in contact with an open flame. In this and many other applications, the flash and fire test made in the laboratory may mean little so far as the suitability of the oil for a given service is concerned.

Cold Test

Cold test of an oil is useful only where the oil may be subjected in operation to low temperatures which would tend to congeal it unless it has a sufficiently low cold test. This test, sometimes called the pour test indicates simply the lowest temperature at which the oil will flow. Specifications for refrigerating machine oils sometimes call for a Pennsylvania crude with a cold test of as low as —5 deg. F. The lowest cold test obtainable with pure Pennsylvania crude is about 25 deg. F. and the only way to lower this is by dewaxing, which makes a very expensive oil. The man who says he is selling you a regular priced oil made from pure Pennsylvania crude with a cold test much below 25 deg. knows not too much about oils.

Horse-Trading in Oils

Years ago in horse-trading, the physical specifications of a horse were its age and its weight. You could tell its age by looking at its teeth and get its weight by putting it on the scales. But the horse trader never bought a horse purely on specifications. He insisted upon a "work test", because he was more interested in what the horse could do than in its physical specifications. If he were buying a trotting horse, he wanted to find out how fast the horse could go and how long he could keep it up. If he were buying a work horse, he wanted to know how much the horse could pull, how fast he could pull it and how long he could keep on working.

Buying oil is almost as hazardous as horse trading. Mistakes are easily made and are mighty expensive. He who buys oil on physical specifications only is likely to have a lot of "lame" oil put over on him.

J. R. Battle, in his well-known handbook, Industrial Oil Engineering, says:

"It is unfortunate that lubricating oils lend themselves so readily to a number of scientific tests because, due to this fact, these tests have become, to a very considerable extent, the common property of operating engineers, oil salesmen, purchasing agents and others not equipped with sufficient knowledge of the refinement of oil to appreciate what the tests really signify."

You should buy oil to lubricate under certain definite conditions rather than to meet certain physical specifications. For no job of lubrication is there one oil of certain prescribed tests which is the only solution.

Safety lies in buying lubricants from a manufacturer who knows through research what is best for each type of service and who sells only the best.

Reconstruction of Induction Motor

By E. W. Johnston

IN REGARD to reconnecting a 220-v. two-phase induction motor to operate on 220 v., three-phase, a brief discussion on the Scott or T connection is in order.

By means of this connection it is possible to change from three phase to three phase or two phase to three phase. The connection for three phase to three phase transformation is shown in Fig. 1. The two windings having primaries *ad* and *bc* and the secondaries *a'd'* and *b'c'* are used. The middle point *d* of the winding *bc* and *d'* of the winding *b'c'* must be accessible. One end *d* of the primary winding *ad* is connected to the middle point *d* of the primary *bc*. The respective ends of the three coils are connected to the three phase supply *abc*. The winding *bc* is the main winding and *ad* the teaser winding.

Referring to the voltage diagram, the three-phase supply is assumed, for convenience, to be 100 v. across the line and the windings to have a one to one ratio. The voltages E_{dc} and E_{db} are each 50 v. and are 180 deg. apart since coil *dc* and coil *db* are both on the same magnetic circuit. Each side of the equilateral triangle is equal to 100 v. The voltage E_{da} is the altitude of the equilateral triangle and is therefore equal to $100\sqrt{3}/2$ or 86.6 v. The same relations hold in the secondary coils so that *a'b'c'* is a symmetrical three-phase system.

Full capacity of the coil, however, is not utilized. The teaser coil operates at only 86.6 per cent of its rated voltage and in coils *bd* and *dc* the current lags 30 deg. in one and leads 30 deg. in the other at unity power factor. This gives a power factor of 86.6 per cent in the coils and is therefore equivalent to operating at only 86.6 per cent of the rated kv-a. capacity. If, however, the teaser is designed for 86.6 per cent voltage, it operates at full capacity and the capacity of the system is

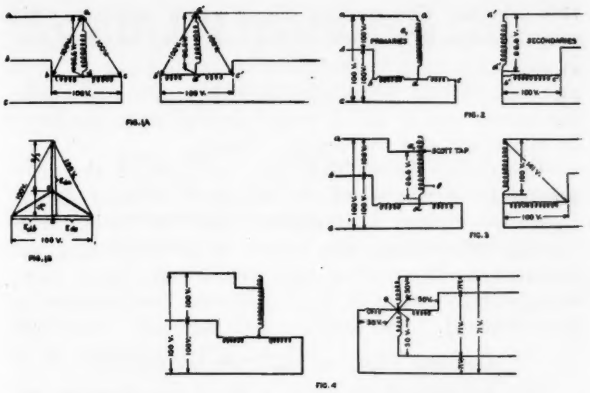


FIG. 1A. CONNECTION FOR 3-PHASE TO 3-PHASE. 1B. VOLTAGE DIAGRAM SHOWS CENTER OF GRAVITY OF SYSTEM

FIG. 2. SCOTT CONNECTION FOR 2-PHASE TO 3-PHASE TRANSFORMATION

FIG. 3. CONNECTION TO UTILIZE FULL CAPACITY OF TEASER COIL

FIG. 4. CONNECTION FOR SYMMETRICAL QUARTER-PHASE SYSTEM

then $(100 \times 0.866 + 86.6) \div (100 + 86.6) = 92.8$ per cent of the total capacity.

If the ends b' and d' of the secondaries be connected as shown in Fig. 2, a two-phase, three-phase system results. The voltage $E_{d'a'}$ is equal to only 86.6 v. whereas $E_{b'c'}$ is 100 v. The resulting two-phase system, therefore, has unequal voltages. This may be corrected, if the line *abc* is connected to point a_1, on the primary of the teaser winding, the point a_1 being such that da_1 represents 86.6 per cent of the total winding of the teaser coil as shown in Fig. 3. This will increase the volts per turn in the ratio of 100 to 86.6 and will raise the secondary voltage to a corresponding amount. The symmetrical two-phase, three-wire system results. By connecting the middle points of the secondaries together, a symmetrical quarter phase system may be obtained as shown in Fig. 4.

In any of the foregoing connections, *d* is not the neutral of the primary, as it is not the center of gravity of the voltages. The voltages, from the point *0*, Fig. 1b and Fig. 3 to *a*, *b* and *c* are all equal. Point *0* therefore is the neutral of the primary system and is two thirds the way down the teaser winding from a_1, to *d* Fig. 3.

Applying the principles outlined above to a 220-v., two-phase motor, in order to reconnect this motor for three-phase operation, 310 v. will be required across the line, whereas only 220 v. are available. As this is only 71 per cent of the required voltage, the efficiency will be only approximately 50 per cent.

Air Cooling with Ice

10,500 CU. FT. FREEPORT DIVISION OFFICE (LONG ISLAND) OF THE KNICKERBOCKER ICE CO. COOLED EFFECTIVELY BY A SYSTEM WHICH COST LESS THAN $800

SUCCESSFUL INSTALLATIONS of air cooling and conditioning equipment in stores, theaters and industrial plants for the purpose of promoting human comfort during hot weather or to give better control over industrial processes have been numerous. Introduction of the ice-cooled conditioner increased the range of application to the smaller user by reducing the installation cost.

Feeling that if ice refrigerated space cooling was practical in a small 500-seat theater, a similar system should be successful in a small store or office, the Knickerbocker Ice Co. made an installation in its Long Island Division office at Freeport, N. Y. The capacity of the main office is 8000 cu. ft. and an adjacent office, also cooled, is 2500 cu. ft., making a total of some 10,500 cu. ft. cooled and conditioned.

Equipment and cooling facilities are extremely simple, consisting of an ice storage or melting tank, shown by Fig. 1, a cold water circulating pump and two unit coolers installed in the office as shown in Figure 3. Water is cooled by spraying over the ice and is then circulated by the pump through the unit coolers back to the tank.

About 10 g.p.m. is circulated through each cooler with a total temperature rise of about 2 deg. F. (from 37 to 39) between the pump discharge and spray nozzles. Coolers are equipped with 1/6-hp., three-speed motors operated by snap switches and at the lowest speed will reduce the temperature of the office to a comfortable figure in from 10 to 20 min. even in the most severe weather. By using higher fan speeds, the temperature may be brought to 20 deg. below the outside temperature but this has been found to be uncomfortably cool. In practice the comfort chart, Fig. 2, is used as a guide.

On the hot days the latter part of July, the temperature of the office did not go above 78 deg. F.

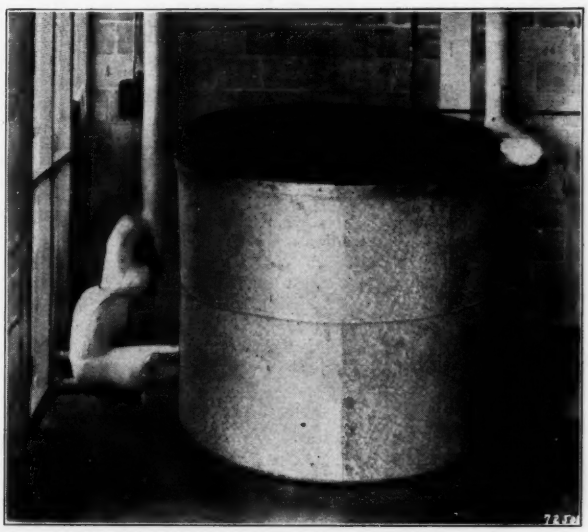


FIG. 1. THE ICE MELTING TANK, 5 FT. IN DIAMETER AND 4 FT. HIGH, WAS INSTALLED IN AN ADJOINING GARAGE

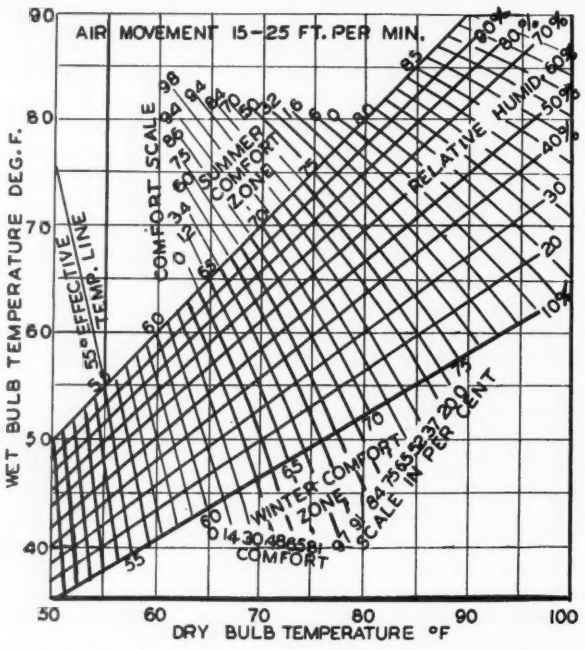


FIG. 2. COMFORT CHART FROM DATA BY THE HARVARD SCHOOL OF PUBLIC HEALTH

with a relative humidity of about 55 per cent. Moisture from the warm air passing through the coolers is condensed and collects in the pans at the bottom of the coolers from where it is drained to the sewer through the ⅜-in. copper tubing visible below the coolers. Tests made on a humid July day showed an actual removal of over a gallon of water from the air.

From 10 to 15 people occupy the office. With one exception, windows and doors are kept closed. One window is opened slightly at the top to supply fresh air. No electric fans of the usual type are used, as the two cooler fans have replaced the three fans previously used. Each of these three fans had a motor equal in rating to the cooler fan motors so no increase in electric power can be charged to the system from this service. The cooling water pump represents the only increase in power consumption. The one installed is oversized to give flexibility in testing but an average installation would require only a ¼-hp. motor, the power cost of which would depend upon the hours in operation and the electric rates.

Cooled air blown over the top part of the room gradually settles down to the floor without drafts. Operation a short while showed that the coolers were usually overcooling the rooms so a thermostat was installed to shut down the circulating water pump automatically when a predetermined temperature has been reached. The fans are still manually controlled.

Coolers Used as Heaters in Winter

The galvanized ice tank is 60 in. in diameter and 48 in. high, with a capacity of about 1800 lb. of ice in 25-lb. pieces. It is insulated with 4 in. of regranulated cork, retained by a sheet iron lagging with 2 in. of sheet cork under the bottom. A hinged double wooden cover facilitates loading of ice. Water is sprayed over the ice by two nozzles.

This system was installed complete for less than $800 making the fixed charges practically negligible. Inasmuch as the coolers will be used as heaters in the winter time by hooking them up with the heating system, part of this $800 investment could be charged to heating.

With power and investment charges negligible, the only significant expense is the ice. The ice used to cool the above office, in very warm weather, with 8 occupants averaged 1500 lb. per 12 hr. operating day. The average consumption during the last four days in July when the outside temperature hovered around 90 deg. F. was approximately 150 lb. per hr. of operation.

Ice is, however, supplied only as needed or required by weather conditions; some days, no ice is needed; other days, only a very little. This favors low operating costs and confines practically the entire cost of cooling to those days when temperature and humidity control are necessary. Furthermore the ice tank pump and coolers occupy a minimum space and can be located anywhere that space can be found. In this case the ice tank is located in an adjacent garage.

FIG. 3. INTERIOR OF THE OFFICE SHOWING LOCATION OF THE HEATERS

First high-pressure boiler and turbine-generator to be installed in the Public Service Electric & Gas Co. system has just been put into commercial operation at Burlington generating station following a period of preliminary tests. Steam generating unit and turbine-generator are the first equipment in this country to employ steam at the pressure of 730 lb. per sq. in. and at a temperature of 860 deg. F.

This new high-pressure exhaust turbine-generator has a capacity of 18,000 kw. and operates at 3600 r.p.m. This is the first turbine-generator of its size to run at such a high speed. It increases the capacity of the station to 53,000 kw.

The new high-pressure boiler, which is fired with pulverized coal, has already produced under test more than 500,000 lb. of steam an hour. The boiler has a greater capacity than the combined output of the 10 boilers now installed in the station, all of which have been shut down since the new unit was put into service. These boilers will be kept in reserve for emergency use.

Parallel Operation of A. C. Generators

Part VI.* Methods of indicating relative speeds between single phase sources by means of lamps. Synchronism and voltage indications from capacitance transformers.

By
E. H. STIVENDER

IN SOME SMALL substations where only single-phase potential transformers are installed, and in certain generating stations where single-phase power is generated, it frequently becomes necessary to obtain the phase relations between two isolated sources of alternating voltage. Several inexpensive schemes may be used whereby "fast" and "slow" indications may be obtained by means of lamps.

In Fig. 1 is a system using a small reactor and resistor, such as the resistor-reactor box of a discarded synchroscope. By observing the time intervals between brightening and darkening of the lamps, a satisfactory indicating scheme can be obtained. Figs. 1 (a), (b), (c) and (d) show the vector relations of the phase angles and voltages in different sections of the indicating scheme during 360 deg. of rotation of vector $E_{A'B'}$, the vector representing generator voltage. A counter-clockwise rotation of $E_{A'B'}$ around the zero point indicates the generator frequency as "fast," hence when the vector diagrams are observed in the order (a)—(b)—(c)—(d) the lamp voltages resulting may be used to indicate "fast." The values given here are where the lamps are

*Parts I to V appeared in the Oct. 15, Dec. 1, 1931, Feb. 1, Mar. 1 and April 1 issues, respectively.

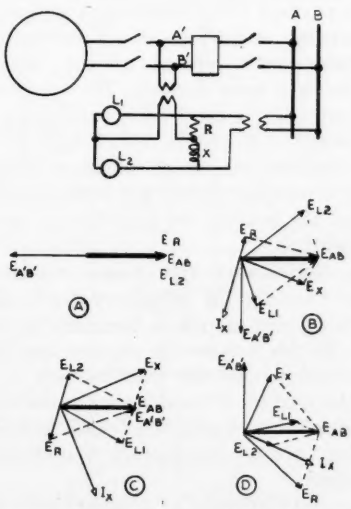


FIG. 1. A CONNECTION WHERE LAMPS MAY BE USED TO INDICATE "FAST" AND "SLOW" FROM SINGLE-PHASE POTENTIAL TRANSFORMERS

(a) Vector relations at synchronism; where RL1 = 1, RL2 = 1, RR = 1, RX = 1. (R symbolizes resistance or reactance.)
(b) EA'B' has rotated 90 deg. counter clockwise.
(c) Relations at 180 deg. out of synchronism.
(d) Relations at 270 deg. counter clockwise.

FIG. 2. RELATIVE MAGNITUDES OF VOLTAGES E_{l1} AND E_{l2} FOR A CONSTANT DIFFERENCE IN THE FREQUENCIES OF $E_{a'b'}$ AND E_{ab}. RESISTANCE AND REACTANCE VALUES AS REPRESENTED IN FIG 1

of equal resistance and equal to the resistance of resistor R and the reactance of reactor X.

In Fig. 1(a) the generator is in phase with the line, E_{L_1} is zero and E_{L_2} is 100 per cent. In 1(b) $E_{A'B'}$ has moved 90 degrees, E_{L_1} is 63.5 per cent and E_{L_2} is 100 per cent. In 1(c) the generator is 180 degrees out of phase, E_{L_1} is 90 per cent and E_{L_2} is 45 per cent. In Fig. 1(d) E_{L_1} is 63.5 per cent and E_{L_2} is 45 per cent. By computing values at 45-deg. intervals, the successive values of E_{L_1} will be:

0—34—63.5—83—90—83—63.5—34—0, and E_{L_2} will be 100—108—100—77—45—18—45—77—100.

These values can be plotted graphically as in Fig. 2, thus representing more clearly the relations existing.

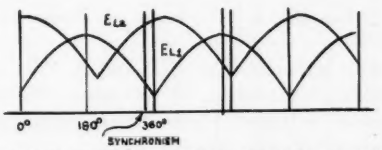


FIG. 3. CURVES OF THE CIRCUIT OF FIG. 1, EXCEPT THAT $R_{l1} = 2$, $R_{l2} = 2$, $R_r = 1$, $R_x = 1$

Voltages are given in ordinates and angular phase displacement in abscissae; here we see that E_{L_2} reaches maximum 135 deg. before E_{L_1}, giving lamp indications in the order L_2—L_1, when the generator is faster than line frequency. The maximum voltage attained across L_2 is approximately 108 per cent of normal generator voltage and that across L_1 is 90 per cent maximum; however, this is not objectionable.

By plotting curves of E_{L_1} and E_{L_2} during several revolutions of E_{L_1} in a clockwise direction, the result will also be similar to Fig. 2, only the lamps will brighten in the order L_1—L_2, indicating the generator as "slow."

If the lamps are of higher resistance than R and X, unsatisfactory results will likely be obtained. The curves of Fig. 3 illustrate a condition where the lamps are twice the resistance of R and X and the voltages reach maximum nearly 180 degrees apart, neither voltage closely approaches zero.

Better results are obtained if the lamp resistances are less than that of R and X, such as in Fig. 4, where L_1

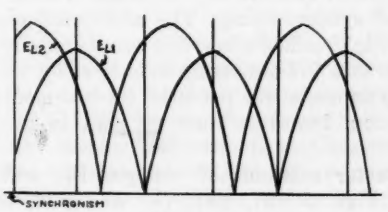


FIG. 4. CURVES OF CIRCUIT OF FIG. 1, EXCEPT THAT $R_{l1} = 1$, $R_{l2} = 1$, $R_r = 2$, $R_x = 2$

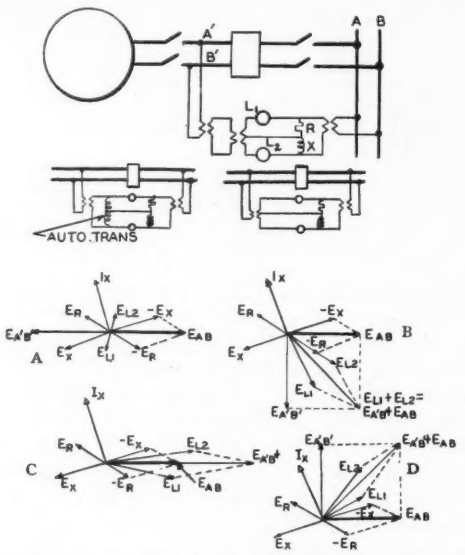


FIG. 5. ANOTHER METHOD OF OBTAINING "FAST" AND "SLOW" INDICATIONS FROM LAMPS, WHERE ONLY SINGLE-PHASE POTENTIAL TRANSFORMERS ARE AVAILABLE

(a) Vector relations at synchronism where RL1 = 1, RL2 = 1, RR = 1, RX = 1.
(b) EA'B' has rotated to 90 deg. counter clockwise.
(c) EA'B' has rotated to 180 deg. out of synchronism.
(d) EA'B' has rotated 270 deg. counter clockwise.

and L_2 are of one-half that of R and X. The maximum voltage obtained across L_2 is 130 while that across L_1 is 112, these voltages reach their maximum values approximately 135 deg. apart.

In order to describe better the indications of relative speeds by means of lamps, we might consider the actual time between bright and dark periods. The short period between greatest brilliancy of L_1 and L_2 in Figs. 2 and 4 is 135 deg. ($L_2 - L_1$) while the long period ($L_1 - L_2$ Fig. 2) is 360 — 135, or 225, that is, the ratio of short periods to long periods is 135 :225 or 3 :5, which is observable when the frequency difference is low. In this manner, it can readily be seen why the curves of Fig. 3 represent undesirable conditions; not only is there not great enough variation in voltage across the lamps but there are no short and long periods between maximum brilliancy of the lamps, hence no definite direction will be indicated.

An advantage of the connection of Fig. 1 when using all equal resistance values, as represented graphically in Fig. 2, is that at synchronism L_1 is dark and hence plainly indicates when the circuit breaker may be closed.

Another scheme which gives satisfactory indications of "fast" and "slow" is that shown in Fig. 5. A small 1/1 transformer is used in addition to the resistor and reactor, the auxiliary transformer need be large enough only to furnish current for the lamps during the short periods of synchronizing. The additional circuit diagrams in Fig. 5 indicate how like results may be obtained by the use of a 2:1 auto-transformer, or by the use of a center tap on one of the potential transformers; particular attention, however, must be paid to ground connections.

The vector relations of voltages E_{L_1} and E_{L_2} are given in Figs. 5 (a), (b), (c) and (d), and when observed in this order show the relative magnitudes of the voltages at 90-deg. intervals as $E_{A'B'}$ rotates counterclockwise through 360 deg., that is, when the generator frequency is faster than that of the line. These values are for a circuit where the lamp resistances are equal to the ohmic resistance and reactance of R and X respectively.

The voltages when taken at 45-deg. intervals are:

E_{L_1} = 22.5—55.5—80.5—93.3—92—77—50—16—22.4.
E_{L_2} = 22.5—29—67—96.5—112—110—92—60.5—22.4.

When plotted in curves as in Fig. 6, it is seen that E_{L_1} reaches maximum 45 deg. ahead of E_{L_2}, hence the ratio of short periods to long periods between maximum brilliancy is 45 deg. : 315 deg., or 1 :7, which will in most cases give better indications than the circuit of Fig. 1.

If it is desired to use the system of Fig. 1 where the potential transformer secondaries are permanently grounded, an additional 1/1 ratio insulating transformer may be placed in the circuit of the generator potential transformer. The circuit of Fig. 1 of course cannot be used without such provision, since some of the circuit will be shunted out through the ground connection. The scheme of Fig. 5 is particularly adapted to installations where grounded secondaries are used—as is generally the case. Figure 5 does not offer the advantage of providing a dark lamp at synchronism but the usual synchronizing lamps can be installed in addition to the speed matching lamps if this indication is desired.

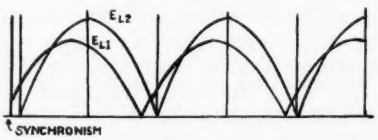


FIG. 6. RELATIVE MAGNITUDES OF VOLTAGE ACROSS L_1 AND L_2 FOR A CONSTANT FREQUENCY DIFFERENCE

Vacuum Tube Synchronizing

Potential transformers for use outdoors on high voltage circuits are often too expensive to use in all cases where synchronizing and voltage indications are desired. In order to provide these indications without incurring excessive expense, a number of schemes using "capacitance transformers" instead of the usual potential transformers have been devised. The capacitance transformer operates like a condenser, furnishing low energy current through a dielectric, which may be the insulation of a standard oil switch bushing. The electrodes may be the conductor within the bushing and a copper band around the outside, from which the secondary circuit is supplied.

Voltage indications and phase relations can be obtained by running the secondary leads directly to a synchroscope, lamps or, where accuracy is not essential, voltmeters. In this manner the expense and maintenance of the customary potential transformers is eliminated. Owing to the output of capacitance transformers being affected somewhat by barometric conditions and temperature, it is not always satisfactory to operate voltmeters by this method.

The secondary current of a capacitance transformer is dependent upon the area of the electrodes, the distance apart, and the strength of the dielectric, hence in order to provide sufficient energy to operate indicating apparatus it may be necessary to place the secondary electrodes too near the high potential lines to maintain

ample insulation. For this reason, certain schemes have been developed whereby the voltages appearing on the secondary are amplified a sufficient amount to allow the electrodes to be placed farther apart, hence none of the strength of the line insulation need be sacrificed in order to furnish the desired indications.

The three-element vacuum tube offers a dependable method of amplifying the power from capacitance transformers. In Fig. 7 is illustrated a method which gives indications by means of four vacuum tubes. A wire from each of the secondary electrodes is run to the grids of 7½-w. amplifying tubes mounted near the oil switch. The output of these tubes is run to a 50-w. amplifying panel in the control room from which the energy for operating the synchroscope is supplied.

The grids of the tubes are biased so as to reduce the flow of grid current, hence the amplified wave will have zero and maximum values similar to the wave of line voltage, producing a current in the indicating apparatus of approximately the same shape as the original wave appearing on the capacitance transformer secondary.

The voltmeter used is in reality a d.c. milliammeter. Its current comes from tertiary windings on the intermediate amplifying transformers, being rectified by small dry copper oxide rectifiers connected so as to rectify both halves of the alternating wave. The purpose of using a d.c. ammeter graduated in volts is to gain advantage of the greater precision offered by d.c. instruments as compared to low-energy a.c. instruments. For initial adjustments, small rheostats are inserted in the rectifier circuits; these are varied to compensate for dissimilar inherent characteristics of the vacuum tubes and attendant apparatus.

To match the phase angles of the two vacuum tube circuits, condensers are placed across the secondaries of the output transformers which supply the synchroscope current. By varying the number of turns shunted by the condensers the pointer of the synchroscope can be moved to the "twelve o'clock" position. This adjustment is especially necessary where one element of the synchroscope is energized from other sources, such as potential transformers in addition to the apparatus shown.

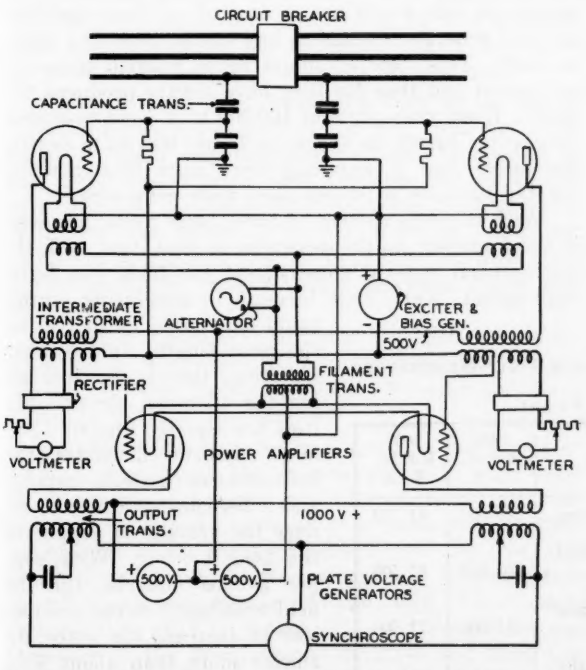


FIG. 7. A METHOD OF AMPLIFYING THE POWER OBTAINED FROM CAPACITANCE TRANSFORMERS, FOR SYNCHRONISM AND VOLTMETER INDICATIONS

The power units used in connection with this scheme are a small 125-v. exciter, a small 1000-500-v. generator and a small alternator. These are on one shaft, being driven by a d.c. motor supplied from the station battery. The exciter, in addition to furnishing field current for the alternator and high voltage generator is used to produce bias voltage for the grids. The alternator furnishes energy to the filament transformers. The 1000-500-v. generator supplies plate voltage for all the tubes.

Induction Motor Operation at Abnormal Voltages

CHECK of the table of effects of abnormal voltages on the action of induction motors published on p. 206 of the issue of March 1 has disclosed errors which Mr. Roe, the author, wishes to correct.

CORRECTION OF TABLE

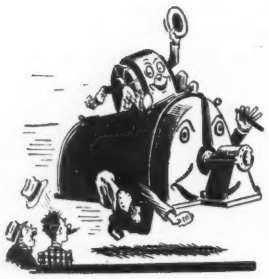
		OVERVOLTAGE				UNDERVOLTAGE					
		10%		25%		9.1%		27.3%		55%	
		+ %	− %	+ %	− %	+ %	− %	+ %	− %	+ %	− %
1	POWER FACTOR		1 1/4		4.7	3/4				1/8	
2	EFFICIENCY	3/4		1			1.4		6 7/8	00	00
3	HORSEPOWER CAPACITY	✓		✓			✓		33		✓
4	SLIP		3/4		35 1/2	21		90		12	
5	SPEED R.P.M.	✓		✓			✓		✓		✓
6	STARTING TORQUE	20		43			18		50		11
7	MAXIMUM TORQUE	20		58			18		50		11
8	TOTAL LOSSES		6		10	14 1/2		73		4 1/2	
	STATOR COPPER LOSS'S		17		27 1/2	22 1/4		117		11	
	ROTOR COPPER LOSSES		17 1/2		31 1/3	22 3/4		97		12 1/2	
	IRON OR CORE LOSSES	18		50			15 1/2		45 1/2		11 1/4
9	MAGNETIZING LOSSES	20		75			17 5/8		50 1/2		8 1/2
10	STARTING CURRENT	10		25			9		✓		5 1/2
11	FULL LOAD CURRENT		✓		✓	✓		✓		✓	

In line 6, starting torque for 25 per cent overvoltage should be +43 per cent. In line 7 maximum torque for 25 per cent overvoltage should be +58 per cent. In line 11, full load current, the check mark for 5.5 per cent undervoltage should be in the + per cent column instead of the — column. A corrected table is given herewith to replace the one in the March 1 issue.

GROSS EARNINGS of the Duquesne Light Co., Pittsburgh, Pa., for 1931, according to its report just issued, totaled $27,805,534.11, a decrease of 3.03 per cent from those of 1930. Output of electricity decreased 9.7 per cent to 1,364,318,513 kw-hr., due to reduced sales to industrial and commercial customers. Connected load, however, was increased to 897,638 kw., a gain of 1.41 per cent. Average use of electric service by residential customers increased to 757 kw-hr. in 1931, a gain of 4.7 per cent.

POWER PLANT ENGINEERING May 1 1932

Setting A New Record *for* Generator Size



Electric Generators built in accordance with conventional design practice are rapidly approaching the limit in size. By means of the radical changes proposed in the article, Westinghouse engineers claim generating units of 375,000 kv-a. capacity are possible.

ELECTRICAL ENGINEERS, as we have remarked before in these pages, are a funny lot. Apparently very serious, well mannered and somewhat reserved, they are always up to something and every once in a blue moon pull what, in the vernacular, is known as "a fast one." They are always careful never to commit themselves and no matter what they do, they always manage to have an alibi.

Take, for instance, the building of electric generators. For years, the electrical engineer has been building generators in sizes that have become increasingly larger. They went about it quietly, never boastful, but always ready with the "goods" when it was demanded of them. When the steam turbine makers built a turbine larger than ever before, the electrical boys were on the job with a generator to match it.

But as we said before, they were slick fellows and would never commit themselves. We remember some fifteen years ago when we stood looking at the first 35,000-kw. generator—the largest ever built—they told us, rather blandly, that that was about the largest generator that was commercially possible; not that they could not build larger units (Oh, no!) but that the size of parts was limited by railway clearances and such factors. You see, they had an alibi.

Well, as time went on they sort of changed their minds a little, forgot about railroad clearances, or maybe they shipped the turbines by air mail, but anyway they began to build larger units, forty, fifty, sixty and even a hundred thousand kilowatt units came to be common. Steam turbine development, of course, went on simultaneously. The tendency in turbine practice was toward the development of large capacity single cylinder turbines, since such machines weighed less and were more economical of floor space than other types. With single cylinder turbine units, however, the limit in maximum output is reached in the turbine before it is reached in the generator. So the multiple cylinder turbine was developed, both in the cross- and tandem-compound types. At present, the tandem compound arrangement of the turbine elements is given preference over the cross compound unit because it requires less floor space, is simpler to start and operate, and is less costly. In the case of the tandem compound turbine unit, the limit in maximum capacity is reached in the generator before it is reached in the turbine.

This again placed the electrical boys on the defensive and it was up to them to prove that further increases in size would not be limited by their inability to build generators to match any size turbine that might be built. This state of affairs never worried them for an instant and thus far they have always produced the goods. Even when units of 160,000 kv.a. were proposed, they never batted an eye so to speak, but built electric generators that if anything were more than matches for the turbines to which they were connected.

With the construction of these large units, however, it was apparent, to the designers at least, that with the conventional type of construction the limit was being approached. Very little increase in generating output could be secured by increasing the rotor length. In the other direction, that is, by increasing the diameter, the possibilities are equally limited. For large diameter machines, the bore stresses increase rapidly and it becomes necessary to reduce the amount of copper in the field winding. With copper as the material for the field winding, it is not economical to increase the rotor diameter more than about 5 to 10 per cent over the maximum values now used.

PRESENT LIMITS OF SINGLE UNIT GENERATORS

(0.8 Power-Factor)

	1800 R.P.M. Kv-a	3600 R.P.M. Kv-a
Conventional design—air cooling	225 000	43 750
Modified design, aluminum field coils—air cooling	250 000	62 500
Modified design, aluminum field coils—hydrogen cooling	285 000	72 500
Multiple-element generator, aluminum field coils—air cooling	375 000	100 000

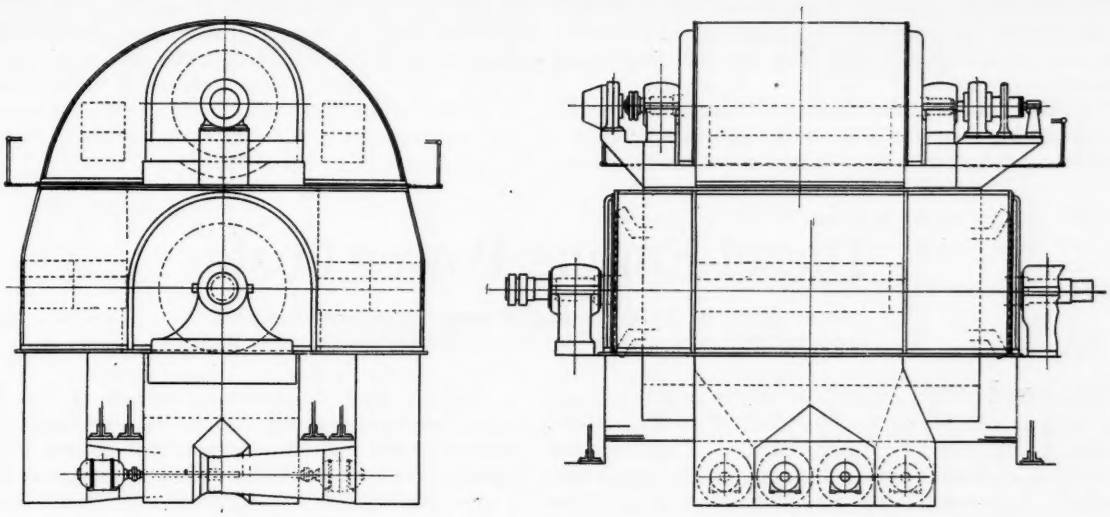


FIG. 1. END AND SIDE VIEWS OF AN 1800 R.P.M. MULTIPLE ELEMENT GENERATING UNIT

These were limitations that could not be ignored, but did they discourage the electrical engineer? Not so you could notice it. These boys are ever resourceful, and take an unholy delight in overcoming obstacles. If larger generators couldn't be built one way, they would build them another way. So they got busy again. They considered the problem.

First, from studies it was quite definite that with the conventional design and using air cooling, the limit of 1800-r.p.m. machines was about 225,000 kv.a. while of 3600-r.p.m. units, it was about 43,750 kv.a. This could be raised by hydrogen cooling. Several years ago hydrogen cooling had been suggested, by electrical engineers, of course—who but electrical engineers would think of using a highly explosive gas in a generator, but thus far no commercial installations have been made. That, however, offered one method by which the capacity could be raised, approximately 15 per cent.

Other methods were considered, such as the use of a modified design using aluminum field coils, but these methods offered only comparatively small increases in size, and it was apparent that if a large increase in size were to be had, a radical change in design must be made. Well, this was according to the electrical engineers' liking—to them life is just one limit after another. And so they sat down, wrinkled their handsome brows and pondered a while.

Eureka! Excelsior! Hot dog or what have you! They had it. By Hector, they would build multiple element generators. Shades of Michael Faraday and Hans Christian Oersted, how simple?

And there you have it—in a couple of nut shells as "Andy" would say. The proposal now is to build units which consist of a main generator of relatively high power factor direct connected to a steam turbine with one or more synchronous condensers, running free, and mounted on top of the generating unit. Perhaps this doesn't sound very startling to you; well, if it doesn't, perhaps this will; by means of this arrangement the engineers of the Westinghouse Electric and Mfg. Co. say they can produce generators having capacities of 375,000 kv.a.!

Let us look into this a bit. As described in the current issue of the "Electric Journal,"[1] this proposed multiple element generator must be considered as a generator, and not just as a high power factor generator used in conjunction with a separate synchronous condenser applied at some point for improving the power factor of the system. The purpose of the multiple element generator is to deliver a certain kv.a. at a definite power factor and to function in the same manner as the usual large single element generator.

With this arrangement several combinations are possible. To obtain a unit of minimum length, the main generator would obviously have to deliver the full kw. rating at 100 per cent power factor and the synchronous condenser proportioned to supply all the reactive kv.a.; however, this results in the two elements being approximately the same size and of minimum length—not the most economical arrangement for the multiple element generator.

A more desirable and economical combination can usually be obtained by dividing the ratings so that the main generator will be capable of delivering the full kw. rating at 0.9 to 0.95 power factor and the synchronous condenser carry 0.2 to 0.25 kv.a. of the combined 1.0 kv.a., 0.8 power factor rating. This permits the use of a smaller synchronous condenser for which the cost per kv.a. is usually less than for the large capacity unit. For this reason the cost of the combined unit will be less than that indicated by the combined equivalent size rating of the multiple element unit. Also, the generator and synchronous condenser elements can be so proportioned that the sum of the losses will not be appreciably higher than for the single unit generator. The decrease in full-load efficiency should not be more than 0.1 per cent. The increase in costs and the reduction in performance efficiency are so small and the reduction in length so great for the multiple element generator that it must be considered when contemplating ultra-large capacity generating units from the standpoint of reducing station sizes and investment costs.

[1] 375,000 kv.a. From One Generating Unit. By C. M. Laffoon. April issue, Electric Journal.

As the main generator operates at relatively high power factor, the excitation requirements per kv.a. output are considerably lower than for the single unit generator.

And so, the electrical engineer knocks another insurmountable obstacle for a row of reactive components. One by one, he has overcome successive limits in size. At one time it was a matter of cooling, at another the problem involved strength of steel, again it was railroad clearances. What it will be next nobody knows, but don't worry, the engineer will get around it when it comes. In the meantime, you can be content with the assurance that you can get a 375,000 kv.a. machine. Order by freight and don't send stamps.

Diesel Engine Power Costs

REPORT OF N. E. L. A. GENERAL POWER COMMITTEE PRESENTS DATA ON 266 PLANTS WITH TOTAL CAPACITY OF OVER 400,000 HP.

PURPOSE of this report is to collect as much actual data as possible on the operation of existing Diesel engine plants and to outline a method of determining operating costs on a proposed plant. In developing this method, the committee has kept uppermost in mind the viewpoint of industrial plant executives for whom cost comparisons usually are prepared. This report contains all of the operating information the committee has obtained up to date.

Table I gives the operating results of 115 Diesel engine generating plants, having installed capacities in excess of 1,000 hp. These plants have a total installed capacity of over 277,000 hp. with a total annual output of over 551,000,000 kw-hr. A portion of Table I is shown to illustrate the type and arrangement of data.

TABLE I. PORTION OF TABLE SHOWING OPERATING COSTS OF PLANTS OF OVER 1000 HP. CAPACITY COMPLETE REPORT GIVES THESE DATA FOR 115 PLANTS

Reference	Years Data Covers	Installation No. of Engines	Installation Total HP Installed	Average Age of Engines	Average Annual Output Kw-hrs.	Peak Load Kw.	Annual Load Factor in %	Yearly Use of Plant Capacity in %	Net Kw-hrs. per Gal. of Fuel Oil	Net Kw-hrs. per Gal. of Lubricants	Fuel Cost Cents per Gal.	Lubricant Cost Cents per Gal.	Costs per Net Kw-hr. - Mills: Fuel	Lubricants	Misc. Supplies Water, Etc.	Attendance	Maintenance & Repairs	Total Operating Cost (Excludes Fixed Charges)
8	1	4	6,500	-	18,465,780	3,200	65.8	57.1	10.68*	3,030	-	-	4.72	0.16	0.72	1.02	0.82	7.45
9	1	6	9,000	-	32,700,500	3,500	67.5	47.3	9.99*	2,700	-	-	6.22	0.25	0.73	0.95	0.91	9.05
10	1	6	1,875	-	2,246,660	949	87.1	19.5	8.37*	500	-	-	4.55	0.28	1.13	7.56	4.92	19.04
11	1	3	1,000	-	2,130,540	625	58.9	33.8	10.00*	572	-	-	4.37	0.97	0.71	1.66	4.02	12.10
12	8	3	1,500	-	6,670,000	-	-	80.0	-	-	-	-	-	-	0.40	-	2.25	-
13	6	3	1,500	-	5,833,230	-	-	66.5	11.02	2,310	5.33	-	4.85	0.34	-	2.50	4.45	12.70
14	1	4	2,000	-	6,331,937	-	-	58.6	10.48	898	9.43	77.7	9.03	0.86	-	1.46	2.62	13.97
15	1	3	1,500	-	3,959,033	-	-	45.2	9.87	-	4.96	-	5.18	1.86	-	2.28	4.75	13.60
16	1	4	2,000	-	6,438,385	-	-	59.0	10.71*	900	9.40	87.7	9.01	0.30	0.04	1.45	2.52	13.99
17	1	2	1,100	-	636,300	-	-	9.6	-	-	-	-	7.76	0.60	-	1.56	2.20	12.12
18	1	5	2,965	-	7,536,640	1,980	43.4	28.6	10.53	-	-	-	5.53	-	-	2.43	0.80	8.76
32	1	2	4,500	2	21,189,100	3,200	76.4	60.4	11.18*	4,440	4.75	71.5	4.08	0.16	0.11	0.84	0.64	5.81
33	3	3	3,450	5	15,796,630	2,300	78.5	78.0	10.88	1,100	2.77	41.6	2.80	0.38	0.12	1.19	0.82	5.31
34	3	4	3,125	5	8,696,627	1,000	50.8	16.5	9.48	1,125	4.90	69.2	5.19	0.43	0.82	4.66	1.74	12.84
35	1	5	2,500	4	6,252,046	800	36.0	39.0	10.87*	960	5.00	54.0	4.84	0.56	1.45	1.92	-	8.77
36	3	3	2,160	-	577,839	1,675	3.9	4.55	2.52	117	4.54	56.3	5.98	1.59	1.56	5.95	6.77	21.97
37	3	4	2,100	3	1,458,211	960	16.9	11.6	11.80	615	5.00	57.4	4.25	0.74	0.98	2.50	0.94	9.39
38	3	5	2,760	4	3,109,989	1,060	33.4	19.8	10.80	1,090	5.52	45.9	5.09	0.43	1.31	3.14	1.90	11.87
39	2	3	1,560	7	2,023,600	700	33.0	21.6	10.25	969	5.20	56.3	3.12	0.56	0.60	3.92	1.15	9.37
40	1	2	1,500	5	4,831,500	1,200	46.0	55.0	11.71*	2,780	3.30	80.5	2.82	0.89	0.26	2.18	0.62	6.01
41	2	2	1,500	5	3,077,923	400	87.5	35.5	10.00	592	2.96	56.7	2.96	0.99	0.12	2.89	0.82	7.83
42	2	2	1,350	5	1,282,648	500	29.3	16.2	11.21	752	2.74	53.8	2.44	0.47	0.22	3.65	0.85	7.63
43	2	3	1,350	4	2,785,992	-	-	35.0	8.24	1,250	3.47	24.9	5.57	0.20	In Maint.	9.93	2.32	18.02
44	3	3	1,225	6	1,301,344	450	33.1	18.6	9.45	735	5.85	47.2	6.19	0.64	1.09	5.26	0.47	13.65
45	1	2	1,200	2	869,500	340	29.2	12.4	7.50*	1,112	6.50	59.5	9.04	0.53	-	4.96	*	14.50
46	1	2	1,200	3	1,200,000	550	25.0	17.2	9.62*	598	5.25	57.5	5.70	0.62	-	9.20	1.15	16.70
47	1	3	1,200	3	1,203,000	-	-	17.3	-	562	5.69	53.6	6.72	0.91	2.92	3.80	-	14.35
48	3	2	1,200	4	1,556,325	980	19.3	21.6	9.35	1,078	4.91	52.2	5.24	0.53	0.93	3.06	1.23	10.99
49	3	3	1,650	5	2,144,490	1,050	25.3	21.6	9.89	875	4.84	57.6	4.89	0.62	0.62	2.36	1.78	10.27
50	1	2	2,500	1	4,381,560	1,600	31.25	27.8	8.90	2,200	1.80	75.0	2.25	0.34	0.26	1.56	0.15	4.56

Examination of the operating cost data appearing in these tables reveals a decided lack of uniform results. Wide variations occur in unit fuel oil and lubricating oil consumptions and in maintenance cost. On this account, it would be poor engineering judgment to base power costs of a proposed Diesel plant on the performance of any particular one of these plants now in operation. A more correct and logical method is by using the costs or quantities obtained from these tables, or similar tables, representing a large number of plants.

OPERATING DATA

The operating data presented in this report have been classified according to the installed capacities of the plants.

Another table, not shown here, gives the operating results of 53 Diesel engine generating plants, having installed capacities of between 500 and 1,000 hp. These plants have a total installed capacity of over 39,000 hp. with a total annual output exceeding 53,000,000 kw-hr.

Still another table, not shown, gives the operating results of 52 Diesel engine generating plants, having installed capacities of under 500 hp. These plants have a total installed capacity of over 18,000 hp. and produce annually over 17,000,000 kw-hr.

A fourth table, not shown, gives the operating data of 31 plants recorded in the report of the Diesel Engine Users Association of England on Heavy Oil Working Costs (1929-1930). This table gives the results of 31 plants having an installed capacity of 37,959 kw. and an annual output of 42,000,000 kw-hr.

Table II gives operating data on 15 mechanical-drive Diesel engine installations, having a total connected load of 20,355 hp. and an annual equivalent production of 33,000,000 kw-hr.

Taken all together, tables of this report present operating data on 266 plants, having a total installed capacity in excess of 412,000 hp. and an annual output of nearly 698,000,000 kw-hr.

Fuel oil consumption for the plants reporting this

TABLE II. OPERATING DATA FOR 15 MECHANICAL DRIVE DIESEL INSTALLATIONS

Reference No. of Plant	No. of Engine Units	Installation Date Installed	Installation H.P. Installed	Equivalent Kw.	Net Equivalent Kw-Hr. Output	Station Load Factor—in %	Lb. Fuel Oil per Kw-Hr.	Maintenance per Kw-Hr. Mills	**Miscel. Cost per Kw-Hr. Mills
1	4	-	2,080	1,375	4,735,000	57.8	0.760	1.40	0.57
2	7	(2-1916 (4-1918 (1-1919	3,040	2,030	6,500,000	46.4	0.668	3.45	0.31
3	6	-	3,405	2,270	8,365,000	54.4	0.711	5.67	0.55
4	3	1924	400	270	1,067,000	79.5	0.764	5.63	1.04
5	7	(5-1917 (2-1921	3,240	2,160	5,160,000	37.0	0.690	3.09	0.54
6	8	(4-1919 (2-1924	2,275	*1,820	990,000	52.9	0.770	1.74	0.75
7	4	-	280	187	334,200	48.6	1.660	5.67	4.25
8	8	(2-1917 (2-1919 (4-1925	2,275	*1,820	582,500	38.7	1.100	2.58	0.78
9	1	1922	750	520	1,542,000	43.3	0.720	1.28	0.98
10	2	(1-1922 (1-1915	615	410	1,172,000	34.2	0.774	1.41	0.90
11	1	1925	800	400-	1,060,003	33.7	0.890	1.37	0.66
12	1	1922	800	400	1,535,000	61.0	0.750	0.93	0.46
13	1	1922	550	365	1,368,000	48.8	0.750	0.41	2.11
14	1	1922	200	132	389,000	34.8	0.870	1.98	1.18
15	1	1913	55	45	45,600	22.8	1.260	5.45	0.48
Totals	61		20,365	13,607	33,146,300				

Note: Average age of engines - 6.2 yr. (Plants Nos. 1, 3 and 7 excluded) Data for one year.

* Includes purchased power
** Miscellaneous cost does not include purchased power

item varies from a production of 2.46 to 13.42-kw-hr. per gal. For the English engines, fuel oil consumption for the plants reporting this item varies from 0.602 to 0.852 lb. per kw-hr.

Plants reporting lubricating oil consumption show a variation in this item from 78 to 5070 kw-hr. per gal. From an inspection of these data, it is apparent that the type of engine, load factor and operating conditions determine to a large extent the quantity of lubricating oil used and these factors, together with a knowledge of the quality of the lubricant, therefore must be considered in estimating this item of cost. The use of centrifuges also affects this quantity. It is apparent that the average cost of miscellaneous supplies, including cooling water, varies greatly between installations.

Attendance Labor

The amount of attendance labor required in any Diesel engine plant varies considerably, depending upon local conditions. It remains a fact, however, that experience has shown that competent labor must be employed if maintenance costs are to remain at a normal figure.

The item of maintenance varies greatly. The maximum figure reported was 45.7 mills per kw-hr. The next highest was 15.0 mills per kw-hr., while some plants reported that maintenance was included with supplies. It is evident, therefore, that conditions affecting the operation of a plant, such as engine sizes, location, cooling water, etc., must be taken into consideration in determining the charge for maintenance and repairs.

Plant Investment

There seems to be a wide variation in the installation costs of Diesel engine plants. Investment costs of 73 Diesel engine generating plants are given 24 of which have been installed since 1925. The data in this table, a portion of which is shown here as Table III, have been segregated in so far as possible to show the sizes of the different units and the date of installation.

Prices on Diesel engines have been reduced during the last 2 yr. In determining the investment required for Diesel engine plants it is important to remember that this should include an adequate building with facilities for repairing the units and sufficient auxiliary equipment so there will be a minimum possibility of service interruptions.

It also should be kept in mind that in order to keep

TABLE III. INVESTMENT COSTS OF A NUMBER OF DIESEL ENGINE PLANTS. COMPLETE REPORT GIVES DATA FOR 73 PLANTS

	Installations Over 1000 H.P. Installed After 1925					
Plant No.	Installation Engine H.P.	Generators	Total* Investment	Unit Investment Per B.H.P.	Per Kw.	Date Installed
38	3-360	3-225 Kw.				1925
	1-750	1-500 Kw.				1927
	1-930	1-620 Kw.	$173,024.00	$ 62.80	$ 96.00	1930
110	2-980	2-676 Kw.	138,960.00	70.80	103.00	1930
113	1-675	1-450 Kw.				1927
	1-1125	1-750 Kw.	137,728.00	76.50	115.00	1929
114	3-600	3-410 Kw.	192,005.00	106.50	156.00	1926-28
122	1-270	1-175 Kw.				
	2-410	2-310 Kw.	131,080.00	119.20	169.00	1930
133	1-380	1-200 Kw.				-
	1-300	1-200 Kw.				-
	1-840	1-560 Kw.				1929
	1-720	1-480 Kw.	280,800.00	125.00	194.70	1929
135	1-500	1-360 Kw.				1925
	1-600	1-400 Kw.	94,160.00	85.50	124.00	1926
131	1-500	1-400 Kw.				-
	1-520	1-400 Kw.				-
	1-1125	1-800 Kw.				1927
	1-1125	1-800 Kw.	394,244.00	120.50	164.00	1927
132	1-395	1-250 Kw.				-
	1-600	1-400 Kw.				-
	3-840	3-560 Kw.	315,016.00	90.00	135.00	1927

maintenance costs within reason it is desirable to use air filters, proper scavenging, correct lubrication and a closed system of water cooling.

Tables have been prepared for the report showing

TABLE IV. TABLE SHOWING ACTUAL COST OF INSTALLING TWO TYPICAL DIESEL PLANTS IN 1930 AND 1931

Plant No. 2 - 80 Hp. 50 Kw.	Cost	Cost per kw.
Engine - 80 hp.	$ 5,537.00	$110.74
Generator - 50 kw.	1,600.00	32.00
Building, foundations and cooling tower	1,680.00	33.60
Pipe and pipe fittings	80.00	1.60
Electrical material	500.00	10.00
Auxiliaries, pumps & compressors	547.00	10.94
Miscellaneous material	440.00	8.80
Freight & transportation	500.00	10.00
Labor, included in above prices	.....	.....
Real estate	500.00	10.00
Engineering and supervision	.....	.....
Total cost	$11,384.00	$227.68

Plant No. 4 - 1,050 Hp. 728 Kw.	Cost	Cost per Kw.
1 - 1,050 engine, generator, exciter, auxiliaries, mufflers, heat exchanger, pumps, cooling tower, 20,000 gal. fuel oil tank and piping connection-delivered and erected	$79,878.00	$109.72
Foundations and pits complete	4,110.00	5.65
Building alterations, concrete water storage tanks and foundations for cooling tower complete -	5,886.00	8.08
Switchboard, all cables and connections	1,192.00	1.64
Incidentals and contingencies	4,499.00	6.17
Real estate -	.....	....
Labor, included in above prices	.....	....
Supervision	3,058.00	4.20
Interest during construction	829.00	1.13
Total cost -	$99,452.00	$136.59

the actual costs of installing five Diesel engine generating plants in the years 1930 and 1931.

Only two of these tabulations, one for a 50-kw. and one for a 728-kw. plant are shown here as Table IV.

In determining the investment cost of a particular plant care should be taken that sufficient capacity is installed to handle the load adequately. Good business management and sound engineering judgment dictate the installation of a plant larger than the expected load rather than one smaller.

Since the Diesel engine has little or no overload capacity, the capacity of the unit should be at least equal to the maximum load which the engine will be required to carry. Ordinarily this will mean that the capacity of the unit should be approximately 20 per cent greater than the highest 15-min. average demand. If allowance is to be made for additional future load, then the unit should be larger in proportion.

In providing spare capacity, units should be so selected that with the largest unit out of service the entire load can be carried on the rest of the units in the plant.

From the data contained in this report, it is not a difficult matter to determine the costs of furnishing power with Diesel engines.

When the characteristics of the power load to be supplied by the proposed plant have been determined, values of the various items making up the total cost may be obtained by selecting from the tables data from plants which most nearly represent conditions likely to be found in the proposed plant. A table may then be prepared which should include all of the items outlined in the report under Factors Influencing Total Cost.

Rock Island Hydroelectric Development

INITIAL INSTALLATION TO INCLUDE FOUR 15,000-KW. ADJUSTABLE BLADE PROPELLER TYPE WATER WHEELS, TWO OF WHICH ARE NOW BEING INSTALLED. BY T. B. PARKER*

ROCK ISLAND Development, located on the Columbia River, about 12 mi. downstream from Wenatchee, Washington, and about 100 mi. east of Seattle and Everett, is the latest development of the Puget Sound Power & Light Co. The station has been planned on this basis of an ultimate capacity of ten 15,000-kw. generating units, with provision for the possible later addition of two more 15,000-kw. units should this prove desirable. The initial installation will be four units, or 60,000 kw.

Discharge of the Columbia River shows a remarkable regularity in its seasonal variations. The larger floods occur in June or July, while from October 1 to April 1 the flow at Rock Island rarely exceeds 100,000 c.f.s. This regularity of flow will make the plant an extremely dependable source of power.

When the dam is completed to its ultimate height, a maximum head of nearly 51 ft. will be available at low water. For larger flows in the river the head is greatly diminished and it is the production of the necessary power under a reduced head that is one of the most interesting features of this development.

At this site the Columbia River divides into two nearly equal branches and flows through a rocky gorge nearly half a mile long. A general plan of the development is shown on Fig. 1. The power house is located in the left, or east channel, at an angle with the direction of flow. It is connected to the east bank by a gravity bulkhead section and with the island by a gate controlled spillway. A similar spillway extends across the west channel.

A cross-section through the power house at one of the main generating units is shown on Fig. 2. This power house has a number of unusual features. It is of reinforced concrete and, together with the headworks, forms an effective portion of the dam. Owing to the necessity of providing for possible extreme high water, all windows and exterior openings have been omitted from the building up to the main deck, which is about on a level with the roof of the generator room.

This condition has made it necessary to provide extensive drainage, ventilating and lighting systems. Seepage through the walls of the substructure is intercepted by tile drains and conducted to a sump, from which it is removed by pumping. The interior of the power house is heated in winter by recirculating the air through the generators and is cooled in summer by exhausting the heated room air and replacing it from the outside through air washers and filters.

Water wheels have been specially designed to suit the wide range in head and are of the vertical shaft propeller type, with adjustable vanes, supplied by Allis-Chalmers Mfg. Co. They are about 18 ft. 7 in. in diameter, with six vanes each, the largest of this type so far installed in this country. Inclination of the runner vanes can be varied to suit the head by a manually operated device extending up through the center of the water wheel shaft. The speed is 100 r.p.m.

These wheels are set in reënforced concrete scroll cases, each of which has three head gate openings each 15 ft. 4 in. wide and 27 ft. 11 in. high. The draft tubes are of the modified elbow type. Although designed to operate efficiently under a head of 48 ft., these wheels will develop 21,000 hp. each, equivalent to normal generator capacity, when the head is reduced to 32 ft. For head of 20 ft., each wheel will produce about 10,000 hp.

Generators are General Electric Co. units each rated at 16,667 kv.a., 0.9 power factor and 13,800 v., 3 phase, 60 cycle. They are of the umbrella type with combined thrust and guide bearing below the rotor. Each stator has an overall diameter of 28 ft. 8 in. An enclosed recirculating ventilating system with surface type air coolers is provided for each main generator.

To supply station service power, a 1,750-kv.a., 0.7-power factor, 460-v., 3-phase, 60-cycle generator con-

*Project Engineer, Stone & Webster Engineering Corp., Boston, Mass.

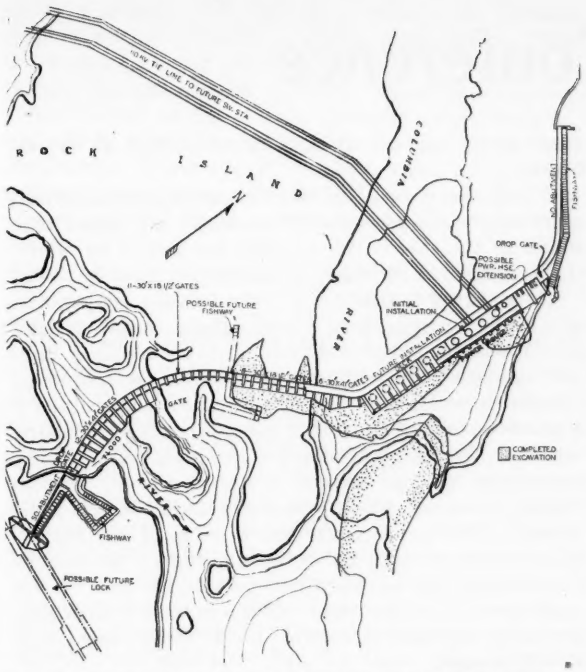


FIG. 1. GENERAL PLAN OF ROCK ISLAND DEVELOPMENT

nected to a wheel of similar construction to the main units is provided. To relay the service generator, a 1,750-kv.a., 13,800/460-v., 3-phase transformer is used.

The 13,800-v. switching equipment and main and station service control equipment are located in the superstructure, on the roof of the generator room. Two banks of three 110,000/13,800-v. single-phase transformers having a bank rating of 30,000 kv.a. with self-cooled operation and 45,000 kv.a. with forced air cooling are provided for the two outgoing high tension circuits.

Spillway in the Rock Island dam consists mainly of a massive concrete sill, upon which are constructed concrete gate piers 7 ft. thick and 30 ft. apart in the clear. The piers are to support a reinforced concrete deck from which the flood gates will be operated.

Gate openings are of two depths, to conform to the elevation of the stream bed. The larger openings have a height of 41 ft. from sill to ultimate crest and the smaller a height of 18 ft. 6 in. The larger gates, of which there are 18, will be installed in two sections, one vertically over the other, while the 19 smaller gates will be in one piece. Initially only the lower sections of the larger gates will be installed, with their tops extending to the level of the sills of the smaller gates. This gives an initial minimum headwater level 18 ft. 6 in. below the ultimate crest.

Flood gates are heavily built of structural steel and on account of the large tonnage involved, they constitute a considerable portion of the cost of the dam. By omitting for the present all of the upper gates, together with the greater portion of the operating deck, it is possible to defer much of the ultimate investment.

To check flow conditions, the discharge capacities of the proposed structures, and the general design of the development, a laboratory model was constructed of the entire damsite. This model was on a scale of 1 to 100 and represented a stretch of river 6000 ft. long and 3000 ft. wide. Upon this model of the site were built models of the dam and power house and water in the proper amounts was allowed to flow over these structures. Experiments were also made with models of cofferdams, to determine the required heights of such cofferdams in both channels under various flow conditions. Test results on these cofferdam models have checked closely with observed water levels at the site resulting from the construction of the actual cofferdams.

Power from the Rock Island Development will be transmitted at 110,000 v. over lines which cross the mountains at favorable points and connect with existing substations of the Puget Sound Power & Light Co. One such line has been in operation between the power company's system and Wenatchee. This line swings to the south and crosses the range at Stampede Pass. A second line has now been constructed, which crosses over Stevens Pass to the north and so forms an independent connection through different territory. These lines are in general of single circuit, H-frame wood pole construction, except for a few steel towers near the summit.

At the present time, the dam and power house have been nearly completed and two of the main generating units are being installed. During the present year it is planned to install Units Nos. 3 and 4 and to finish all construction and incidental operations in connection with the initial development.

Stone & Webster Engineering Corp. have the contract for the design and construction of the entire development. All construction is under the general direction of H. F. Anthony, project manager. R. E. McGrew is superintendent at the Rock Island Development and T. H. Campbell superintendent on the transmission line construction.

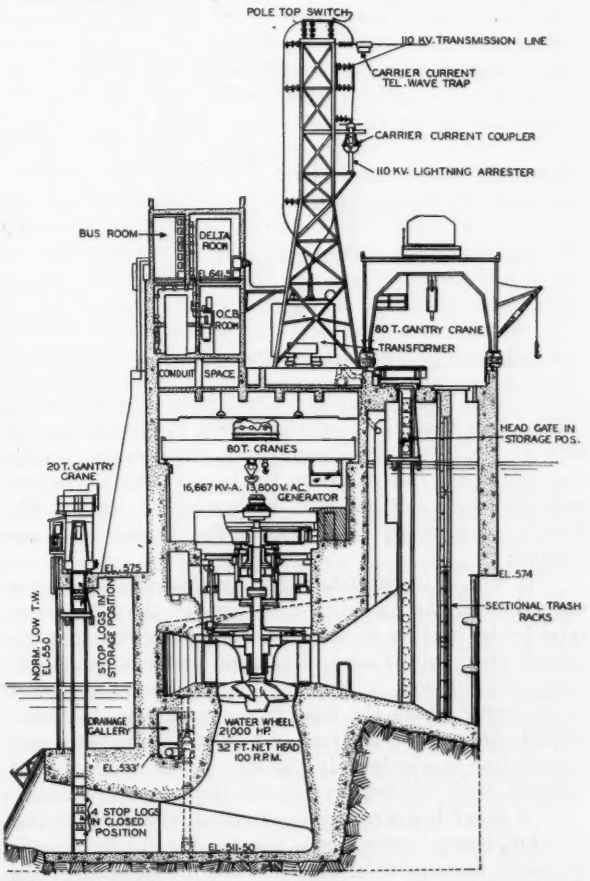
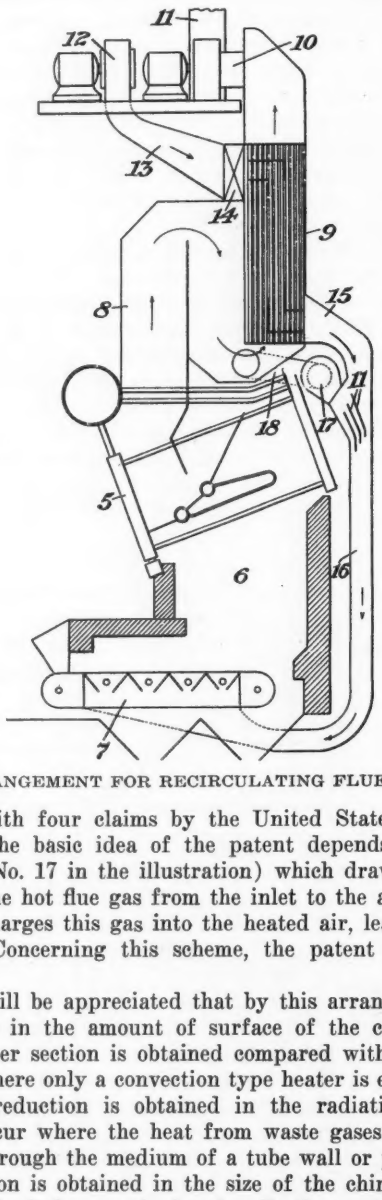


FIG. 2. CROSS-SECTION THROUGH ONE GENERATING UNIT AT ROCK ISLAND

Readers' Conference

Does Heating Air by Direct Contact with Flue Gas Pay?

IN THE ILLUSTRATION reproduced here from a Patent Office drawing is a typical modern chain-grate stoker and boiler setting with a tubular type air heater together with forced and induced draft fans. Inasmuch as none of this equipment is basically different from that found in thousands of power plants in the country, it is surprising that the inventor was recently granted a



ARRANGEMENT FOR RECIRCULATING FLUE GAS

patent with four claims by the United States Patent Office. The basic idea of the patent depends upon a blower (No. 17 in the illustration) which draws a portion of the hot flue gas from the inlet to the air heater and discharges this gas into the heated air, leaving the heater. Concerning this scheme, the patent reads as follows:

"It will be appreciated that by this arrangement a reduction in the amount of surface of the convection type heater section is obtained compared with that required where only a convection type heater is employed. Also, a reduction is obtained in the radiation losses which occur where the heat from waste gases is transmitted through the medium of a tube wall or plate and a reduction is obtained in the size of the chimney and induced draft fan required to handle the waste gases.

"A lower temperature is provided within the boiler furnace, hence longer life is insured for the brickwork, grates or burners resulting from the intermixing of the waste gases and air in the contact section of the air heater.

"It is also to be noted that this arrangement permits carrying the temperature of the heated air higher than would be the case if the air were not heated by admitting a portion of the gases of combustion directly to it."

Attempting to produce a lower furnace temperature in a boiler setting seems a particularly erroneous idea. In oil refineries where convection type cracking units are employed, recirculation of flue gas is frequently adopted in order to reduce the furnace temperature to a point where the tubes will not be in danger of burning out. This is more effective and also more efficient than using a large amount of excess air. In a boiler furnace, however, where water circulation in the boiler is good, there is no advantage in reducing the furnace temperature. We all know that the higher the furnace temperature can be raised, the greater the rate of heat transfer to the boiler water. If the furnace temperature is too high for the refractories, air or water cooled walls should be used.

Whatever benefit may be derived by increasing the temperature of the air leaving the heater by mixing it with flue gas, is more than offset by the presence of the inert flue gas. Referring to the illustration, if we assume that coal is being burned on this chain grate stoker with anything like good efficiency, the gas should contain from 15 per cent to 16 per cent CO_2 at the top of the furnace. With no leakage through the setting, practically this same percentage of CO_2 should enter the air heater. With 15 per cent CO_2, about 3 per cent oxygen and about 82 per cent nitrogen should be obtained. In other words, the flue gas which is introduced with the air will be 97 per cent inert gas which will not support combustion. Furthermore, CO_2 is an excellent fire extinguisher. Its introduction into the furnace tends to retard combustion. Another disadvantage of mixing flue gas with the combustion air is found in the fact that the flue gas usually carries a certain amount of soot and ash which will tend to clog the air passages in the stoker grate.

The inventor claims a reduction in radiation losses with the arrangement of apparatus shown. It should be noted that the flue gas is brought out of the top of the boiler into a box-like breeching which is baffled to send the flue gas up the front half and down the rear before entering the air heater. Besides the unnecessary draft loss due to four right angle turns, there must be some radiation loss from this breeching which could be avoided if the air heater were set directly over the gas exit from the boiler.

There is no system of heat transfer having 100 per cent efficiency and the plant designer must decide whether it is more efficient to attempt recovery of heat in flue gas directly or indirectly.

It is doubtful that the returning of a portion of the flue gas to the furnace along with the combustion air will permit a reduction in the size of the chimney and induced draft fan. On the contrary, it would appear that a larger chimney or induced draft fan will be required. Introduction of inert gas with its tendency to

act as a retarder of combustion with lower furnace temperature will result in poorer combustion. This means that a greater amount of coal must be burned to produce the same amount of steam. The greater amount of fuel burned means a larger quantity of products of combustion which the induced draft fan or chimney must handle. The net result will be not only an increase in power consumption for the induced draft fan but lowered over-all thermal efficiency for the combined unit.

Chicago, Ill. J. R. DARNELL.

What Are Interest and Depreciation?

DISCUSSION of fixed and operating expenses, by Mr. Gavit on page 180 of the Feb. 15 issue, is an excellent one and sets forth the issue very clearly. That does not mean that I agree with him in all cases, however, because I don't, with the exception of figuring maintenance as part of operating expense. It is just that and should never be figured as a fixed charge. If it could be fixed by some means, it would be a big relief to us, though.

As to interest, it should and should not be figured in, depending upon conditions and the results wanted. If a man got a two-year contract for trucking, which required a $3000 truck and, after figuring labor, operating expense, maintenance and depreciation based on a reasonable salvage value, he figured he could make $75 a month, he might naturally figure he was making $900 a year or 33.3 per cent on his $3000 investment. He would hardly be justified in figuring that by buying the truck he was losing 8 per cent interest or $240 a year that he might have obtained from his $3000 on a first mortgage. Certainly he could not figure the $240 as an expense. But he might figure he was making $900 — $240 = $660 or a return of about 22 per cent more from his investment in the truck.

But if he was a contractor who had to have trucking done and had to decide whether to invest $3000 in a truck to do his own hauling or invest his money in a mortgage and hire his trucking done, he might be justified in adding the $240 interest to find out what it would actually cost him to do his own trucking as compared with hiring it done. If he bought the truck, however, the $3000 would simply increase the capital investment in his business. He has a certain amount invested in a business in order to make more money and he would hardly be justified in figuring in, as a real expense, interest that he lost by not investing the money elsewhere.

That is the way with a power plant, unless it were set up as a separate operating company, in which case the interest might be added in but called a reasonable profit. What I said in the earlier issue was that when comparing two methods of investments, I preferred that method of figuring that does not include interest in the setup but figure in all the other expenses including depreciation and find out what return on the investment could be expected.

This can be used only when comparing two possibilities but usually the case can be reduced to two possibilities by other comparisons such as reliability, design, etc. In general, there are three methods of comparison: figuring the per cent return on the investment; comparison of annual cost including interest on the investment; capitalized cost. I prefer the first because it is easier to explain and involves one less assumption. You assume a depreciation rate, usually out of thin air, and if you add interest you involve another assumption that has little real meaning. With the same assumptions, all three methods will give the same result.

Depreciation, of course, plays an important part in all three methods. I do not agree with Mr. Gavit that "the particular method used, however, in determining the rate used in charging depreciation is of no special interest to the plant engineer." Unless the engineer is in such an unfortunate position that he must take what is given to him, without any voice in the matter, it makes a lot of difference.

Using the sinking fund method with the usual published life tables is a favorable way for the engineer because it puts depreciation low. It is the thing that we all like to do on estimates if it can be done legitimately. But it seems to be the opinion among engineers and accountants that these expected life tables are worse than useless and even the courts, it is reported, are looking with displeasure upon their use. What happens when you come up against the executive argument "but our depreciation rate is 10 per cent. Equipment purchased 6 or 8 yr. ago is obsolete now. How can we expect to spread the payments for this new material over 20 yr. when new conditions or changes in product or methods may make it necessary to discard or sell it second hand in two or three years?"

Then there is the matter of book value of replaced equipment. Mr. Gavit says add it to the cost of the new equipment. But upon what authority? It certainly sounds like the logical and reasonable thing to do but is it the proper way? Vorlander and Raymond, talking before the American Society of Mechanical Engineers last November on the economic life of equipment said that this balance could be taken care of in three ways: written off to profit and loss; included in overhead; added to the cost of new equipment.

Grant, however, in his book Principles of Engineering Economy (reviewed in the Oct. 1, 1931, issue of Power Plant Engineering) says that the book value of the old equipment, being a "sunk" cost, must not be considered in an economic comparison except from its salvage value. Any difference between the book and salvage values means that the wrong depreciation rate was guessed in the first place. He further says that an economic analysis between old and new equipment is the same as a comparison of (old) equipment costing the salvage value and new equipment at its regular cost, both, of course, at their respective operating costs.

Now in the end, of course, it doesn't make any difference how it is handled because the same pocket pays for it anyway but in figuring it makes a lot of difference if you are trying to figure the return on investment. In an example in the book, adding the old book value to the investment shows a return on the investment of 8.3 per cent whereas the method as figured by Grant shows the correct return to be 17.2 per cent, a sizable difference.

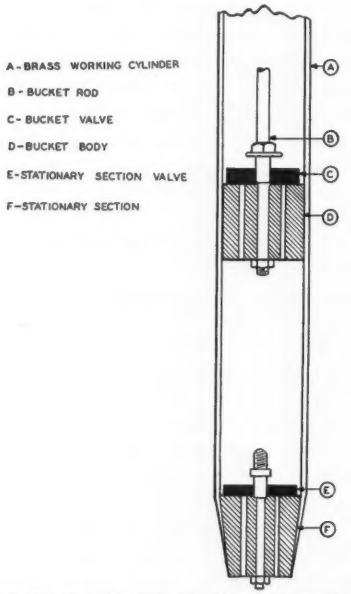
In the two or three cases that I have had a chance to get figures on, it works out right for replacement studies. I'm convinced that adding the book value of old equipment to the cost of the new equipment is the wrong way for studies of this kind. Also I believe that the only depreciation rates justified are those being used by the accounting department, probably 10 per cent in most cases today.

If depreciation is figured as a real expense and is calculated in estimates as 2½ or 3 per cent from low interest rates and high expected life, it does not check well with actual costs at the end of the year when the accounting department uses 10 per cent. And the books are always right in spite of explanations, which are easily forgotten, especially when you are not around to defend the figures. If your estimates are much lower than actual costs you may have a difficult time getting something through the next time.

Brooklyn, N. Y. P. F. ROGERS.

Trouble with Deep Well Pump Valve

WHILE AT a mountain resort wiring up and putting into operation two automatic pumping outfits, a deep well outfit with a drop pipe, taking water from a well 180 ft. deep, failed to draw water. It was evident that



DEEP WELL PUMP VALVES IN CASING

something was wrong. According to the workman who installed it he had followed every instruction to the letter. Consequently the plunger was pulled out section by section and then the casing was removed to see if it had been damaged when it had been lowered into the well. It had dropped several feet onto the rock bottom but the drop had not damaged the casing or valves to any extent. When the plunger was removed it was found that the lower valve cage was still fastened to the plunger, when in reality it should have been driven into the tapered lower end of the brass casing. The reason for this form of construction is for ease in replacing valve disc. There is no necessity when this construction is used of pulling the casing to replace a defective or worn disc. The plunger is unfastened at its drive support and lowered and screwed onto the lower valve cage. Then this cage is pulled up with the plunger and both upper and lower valve and cages may be inspected or repaired.

When replacing, the plunger is lowered into the casing and the cage is driven into the tapered lower end of the cylinder. The bucket or moving valve cage is unscrewed from the stationary cage and the plunger fastened to the crosshead. After the packing gland is replaced, the pump should be ready for operation. After we had done these things in proper order, no further trouble was experienced. For those unfamiliar with deep well pumps, a sketch is given showing working parts of cylinder.

Birmingham, Ala. GRADY H. EMERSON.

Diesel Engine Upkeep

FROM EXPERIENCE with a considerable number of compressors for Diesel engine fuel injection, I cannot fully agree with the article on "Avoiding Troubles with Air Compressors," by Edward J. Kunze, in the issue of March 15, 1932. I do not think that a considerable change in the clearance of the high-pressure stage would affect the performance of the compressor to any great extent, though I can see that an increase in the low-pressure clearance would do so, for it is the volumetric efficiency of this stage that determines the weight of air delivered by the compressor. In many cases much trouble can be avoided if the clearance of the high-pressure cylinder be considerably increased, and in extreme cases also the clearances of the intermediate and low-pressure stages as well.

Particular cases I have in mind are those in which the engine requires a greatly reduced output from the compressor for correct fuel injection, yet, due to the fuel or the atomizing device used, the pressure required is almost normal, the engine operating under these conditions for long periods of time (several months).

For instance under normal conditions, the high-pressure stage is 1000, the intermediate pressure 240 and the low pressure 45 lb. gage. Under average conditions these pressure ratios should not give trouble; but if under the changed conditions the high pressure is 900, the intermediate pressure 100 and the low pressure 25 lb. gage, trouble can be expected from the overloaded or rather high temperature condition existing in the high-pressure stage. In some installations fires and explosions have been numerous when operating under such conditions.

To avoid this, the pressure in the low-pressure stage should be increased so that a safer ratio exists in the high-pressure stage. This can be done by allowing air blow to waste from the high pressure, but on large units this is an expensive waste of power. This waste can be avoided if the clearance of the high-pressure stage be correctly increased, and due to the built up construction of the high-pressure piston, such an adjustment is easily and quickly made. Then the intermediate-pressure stage pressure will increase and thus lower the ratio of compression in the high-power stage to a safe value. In cases where this would raise the ratio in the intermediate-pressure stage too much, a similar increase can be made in this clearance. Not much loss in power results, because work will be returned in the re-expansion of the increased clearance volume; nor will the increased cylinder clearance of the high-pressure stage greatly affect the output of the compressor should it be necessary to run at full capacity. But if the clearance of the low-pressure stage was changed, the output would vary accordingly.

Globe, Ariz. J. J. MCDOUGALL.

Plant Operation Problems

Information on Cleaning Steam Desired?

CONSIDERABLE difficulty has resulted from the fouling of superheaters and turbine blades with scale-forming impurities in the steam. It is recognized that the character of the boiler water, frequency of blowing down, type of boiler and rate of evaporation have much to do with the amount of solid materials in the steam but as a sort of final touch in the generation of steam many plants are now using steam purifiers in their boilers or steam separators in the lines between the boilers and superheaters. Growing interest is noted among power plant engineers in the application of these devices and a discussion of their value by engineers who have had experience with them will be appreciated. Some of the questions being asked are: Under what conditions is it found advisable to install them? Did they eliminate scale in superheaters? How much did they lengthen the period of inspection and cleaning of turbines? Was the period of blow down affected by the installation of the steam purifying device? How frequently must the purifier be cleaned? How is this cleaning done?

Motor Operation Problems

REFERRING TO THE questions under this heading appearing on page 183 of the February 15 issue, I am submitting my views on several of them. With regard to the first question, by removing the collector rings and connecting the rotor terminals together the rotor would become virtually a squirrel cage rotor. If the terminals were connected together suitably and given the proper voltage, the motor should work as a squirrel cage motor and be self starting. As the motor would be designed to start with a resistance in the rotor circuit, the plan proposed would probably lead to uncertain starting. Proper squirrel cage motors are designed to start without resistance in the rotor circuit, and as the rotor design is different from that of a wound rotor, it is improbable that a wound rotor would start readily when connected as a squirrel cage rotor.

2. A two-phase motor could be operated on a three-phase circuit, but only two of the three phases could be connected, and the remaining phase would have to remain disconnected. The connection would be difficult but not impossible; the motor could be connected to two of the phases and run as a two-phase motor, provided the frequency and phase sequence was right. The efficiency of the motor would, I think, be unaffected but the efficiency of the three-phase circuit would be reduced, as only two instead of three phases would be working.

3. For preventing oil and grease being thrown from a chain and sprocket, have the chain drive totally enclosed in a proper chain case of the form now largely used for enclosing chain drives.

5. The horsepower of a motor should at least equal the average load, in this case with 5.5 hp.; the only satisfactory motor would be one of this horsepower or preferably 6 hp. If a 5-hp. motor were used when maximum loaded, it would have an overload of 1.8 hp.; this is over 25 per cent and would be too great. Electric motors have a large overload capacity but only for brief periods. The motor would when running on average load be overloaded 5 per cent, which is too much for continuous running.

6. A 20-hp. slip ring motor cannot be expected to run at 25 hp. for long at a regular speed, although this depends largely on the duration of the overload and the overload capacity of the motor. Wide speed variation without loss of efficiency is not a property of slip ring motors. A variable speed is obtained only with a loss in efficiency. The motor is under power; this could not be remedied by a controller, the only satisfactory solution would be to install a larger motor, having an excess of power over 25 hp. to allow for lost efficiency.

Herts, England. W. E. WARNER.

Increasing Torque in an Induction Motor

I WAS INTERESTED in the following problem which was presented on page 183 of the February 15 issue:

"In case a wound-rotor motor whose collector rings have been removed and rotor terminals securely tied together occasionally fails to start when the proper voltage is applied to the terminals, what is the cause and what the remedy?"

This problem interested me and my solution follows:

In case a wound-rotor motor has had its slip rings removed and its rotor terminals securely fastened together, it has, in effect, been converted into a squirrel-cage induction motor; therefore it now possesses the common fault of all such motors—a poor starting torque.

In order to keep the starting current within a limit of safety, it is necessary to use a considerably reduced voltage when starting. Since the torque is nearly proportional to the voltage impressed, a low-starting torque results. There is little doubt, then, that this inherent poor starting torque is the reason the motor fails to start when proper voltage is applied to its terminals.

The only practical method of remedying this fault is to mount a variable resistance on the rotor itself. The resistance could be set to limit the starting current at full-load voltage. An increased power factor and starting torque would result.

Bozeman, Montana. MICHAEL W. DRAZICH.

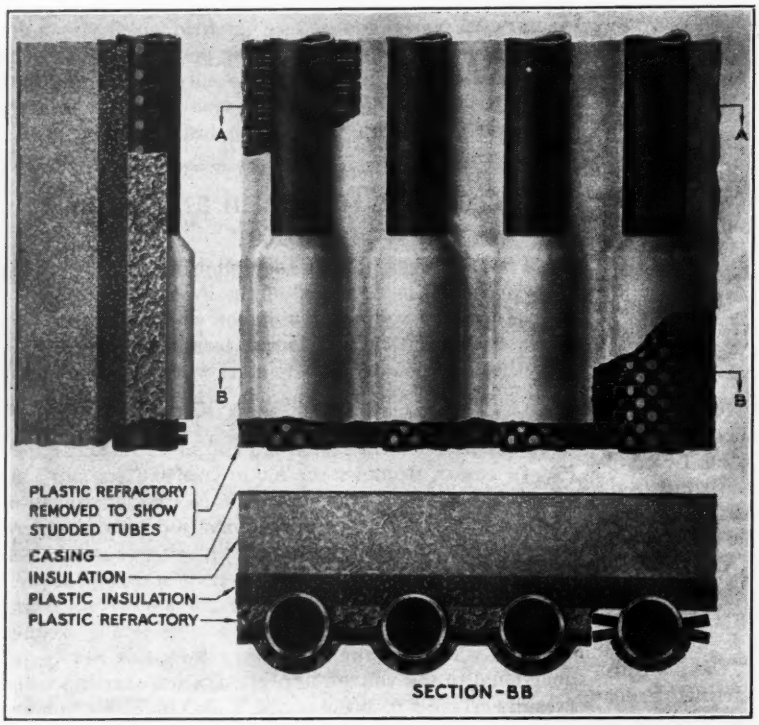
EARNINGS of three companies for 1931 are reported by John J. O'Brien, president of Byllesby Engineering and Management Corp., as follows: Wisconsin Public Service Corp. and subsidiary, gross, $5,514,448; net, $2,399,968; increase in net, $86,121 or 3.72 per cent. The Philadelphia Co. and subsidiaries, gross, $56,036,779; net, $28,240,073; decrease in net, $1,748,754, or 5.83 per cent. Wisconsin Valley Electric Co. and subsidiaries, gross $2,326,253; net $986,676; increase in net, $78,402, or 8.63 per cent.

MAGNESIUM is now passing through the same stages as did aluminum. In 16 yr. it has declined from $5 per lb. to 30c.—Chemical Digest.

New Equipment

Stud-Tube Furnace Wall

DEVELOPMENT of a new water-cooled furnace wall construction, the Bailey stud tube wall, is announced by The Babcock & Wilcox Co., New York. As shown, the lower portion of the wall is completely coated for use in the hotter portions of the furnace and those zones receiving severe punishment. The wall construction consists of water-cooling tubes spaced in the usual manner but instead of being fitted with Bailey blocks clamped in place, iron studs are welded to the tubes and plastered over with refractory of suitable conductivity and thickness to give the desired rate of heat transfer and close the spaces between the tubes to make an air-tight wall.



DETAILS OF FURNACE WALL MADE WITH STUD TUBES

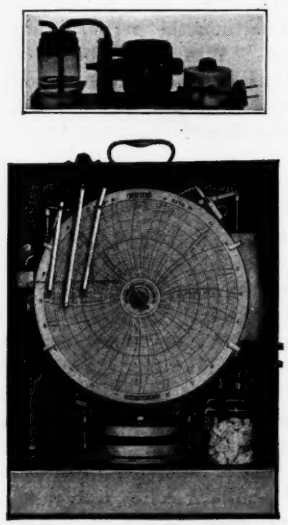
The upper portion of the wall as illustrated, in which the tubes are left exposed, represents the construction used in the cooler zones or the upper portions of most furnaces where rapid heat absorption can take place without interfering with the efficiency of the furnace. The studs are confined to the spaces between the tubes, thereby filling the gaps and these studs when covered with refractory complete the wall. Insulation held in place by a casing is mounted on the back of the stud tubes.

The studs welded to the tubes serve as a mechanical means of securely holding the refractory and slag coating to the tubes and as conductors of heat from the wall coating into the water-cooling tubes. The coating affords protection to the tubes in furnace zones of exceptionally high temperatures. The thickness of the wall coating may decrease due to a thinning down of the refractory or it may increase with the building up of slag or ash but, in all cases, it is stated, the surface of the coating is close to the equilibrium temperature representing the fusion point of the fuel burned. The new wall structure is claimed to be highly resistant to slag action.

Tubes can be bent to any desirable radius to form arches, openings for burners, access and observation doors and form bends or other curved wall surfaces.

Portable CO_2 Tester

PORTABLE recorders and indicators are embodied in a new line developed by Defender Automatic Regulator Co., either as separate instruments or combined with temperature and draft records. The arrangement for the 3-pen instrument shown gives records on a single chart of CO_2, furnace draft and flue gas temperature, the chart being full 10 in. in diam. CO_2 range is from 0 to 20 per cent, draft from 0 to 1 in. and temperature from 0 to 900 deg. F. This equipment is 16 by 12¼ by 7¼ in. and weighs 23 lb. The CO_2 determination is by use of caustic potash solution contained in the tank at the bottom, a flat rubber gasket being clamped on top of the tank when carrying the apparatus to prevent splashing.



FLUE GAS SUCTION AND FORCE PUMP. THREE-PEN CO_2 AND DRAFT RECORDER

Other combinations are for CO_2 indicator alone, for CO_2 and draft indicators, or for CO_2 Recorder alone or with draft record. For

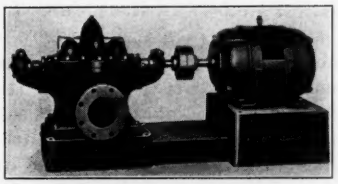
these, the dimensions are 12½ by 9¾ by 5¾ in. and weigh from 12 to 13 lb.

Gas is drawn through the analyzer by a motor-driven gas pump injector of centrifugal type which is a separate unit 10 by 3½ by 4 in., weighing 4 lb. The motor is 1/100-hp. for a.c. or d.c., 110 or 220 v., speed being controlled by the rheostat at the right. Gas is drawn from the boiler by the pump in the center and forced through the bubbling bottle at the left, to the analyzer.

For locations where it may be more convenient, a water-wheel driven injector is available but the motor-driven outfit is to be preferred for convenience and wider applicability.

New Centrifugal Pump

THIS NEW Fairbanks, Morse & Co. centrifugal pump is a split-case model, with stream-lining of flow to give a high efficiency and reduce cavitation with the resultant pitting.

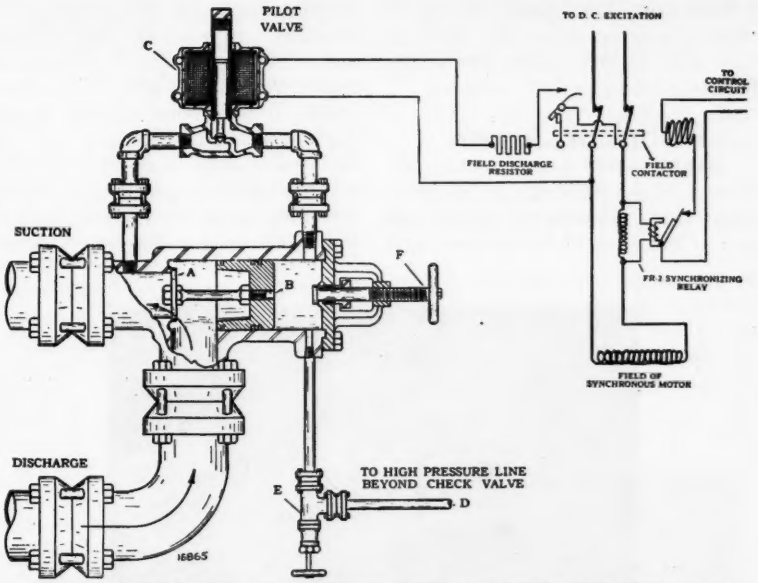


F-M. FIG. 5803 PUMP

Mechanical features are: Ball-bearing construction of cartridge type making it possible to remove the entire rotating element without disturbing alinement or getting dirt into bearing housings. Large stuffing-box, scientifically sealed and lubricated. Heavy casing wearing rings, prevented from rotating by a semi-circular locking collar. Heavy, removable impeller wearing rings, fitted onto the impeller eyes. Extra-heavy shaft sleeves to hold the impeller in a permanent longitudinal position, these sleeves being held in place by long hexagonal nuts which also serve as water throw rings and bearing pullers. Bases of the drip-lip variety.

Automatic Unloader for Compressors

NEW ECONOMIES are made possible for ice and refrigeration plants with the recently developed automatic instantaneous-unloader of the Electric Machinery Mfg. Co., Minneapolis, Minn. This unloader, which is primarily for application to synchronous motor driven ammonia compressors, automatically bypasses the compressor when it is started up. In conjunction with automatic motor control, it permits the operator to start the compressor unit by merely pressing the starter push button, eliminating the need of manually operating bypass valves in starting.



ARRANGEMENT OF ELECTRIC MACH. MFG. CO. AUTOMATIC UNLOADER

Three important advantages are obtained: by brine thermostats, suction pressure control, or other means; freedom from shutdowns due to momentary power line disturbances; releases the operator from maintaining constant watch on the compressor and motor.

This is an automatic, pressure-differential-operated bypass valve connected between suction and discharge on the compressor. The valve operates by ammonia gas pressure differential and is controlled by a magnetic pilot valve which in turn is controlled by the frequency-responsive relay on the synchronous motor starting panel.

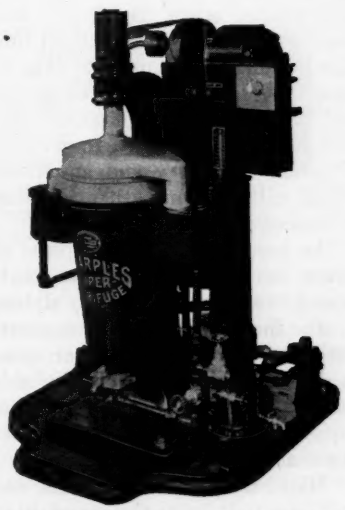
When the motor is started, the pilot valve is energized and a small amount of high-pressure ammonia gas is admitted to the unloader to actuate it. This gas is returned to the low-pressure side of the system so there is no leakage or waste. No springs are used and the mechanical construction is simple.

En Bloc Oil Purifying Plant

DESIGNED especially for purification of Diesel engine fuel and for lubricating oil for turbines, engines and other machinery a new model complete oil purifying plant is announced by the Sharples Specialty Co. of Philadelphia.

This model combines an oil purifier of high centrifugal force with pumps, heaters, push button controls and accessories, mounted on a common base and piped and wired so that the installation requires but two pipe connections and one electrical connection.

The Super Centrifuge of the enclosed vaportite model developing

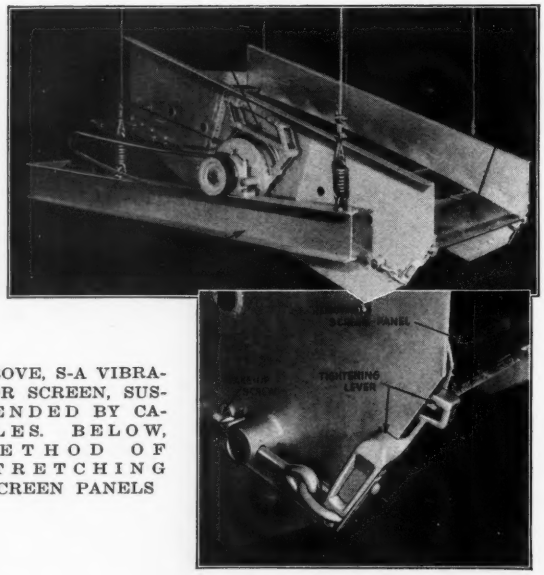


SHARPLES EN BLOC OIL PURIFIER

a force over 13,000 times gravity, is used to remove impurities such as dirt, grit, carbon, sludge and water from the oil.

Vibrator Screen

AFTER SEVERAL HUNDRED efficiency tests, proving the definite relationship between the nature and size of material to be screened and the amplitude, frequency and angle of vibration, the new S-A Vibrator screen was built by Stephens-Adamson Mfg. Co. It has positive vibration, rigid screen body with one or more decks being given a vibration of fixed amplitude by the rapid throw of an eccentric shaft.



ABOVE, S-A VIBRATOR SCREEN, SUSPENDED BY CABLES. BELOW, METHOD OF STRETCHING SCREEN PANELS

Vibrating mechanism is self-contained, factory adjusted, including an eccentric shaft, adjustable balance wheels, heavy double row ball bearings, grease seals and rigid tubular housing. With definite data on materials, sieve analysis, capacities and characteristics, vibrating unit and drive are assembled to give the vibration frequency and amplitude which will prevent either blinding or excessive bouncing.

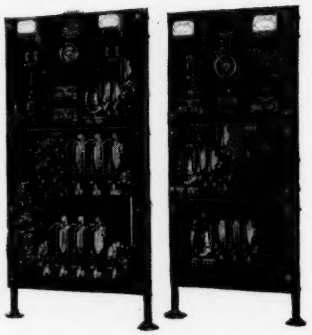
The panel is a full size piece of screen cloth with a stiff cross angle brazed to each end, placed by sliding it up the tubular deck supports until the ends of the upper cross angle drop into sockets in side frames. Stretching levers are slipped on the ends of the lower angle and tightened as shown.

Made up of parallel arms, the stabilizer unit holds the screen body without corner balancing springs or bumpers and connects screen body and subframe so that the screen is free to vibrate, yet is held at a given angle. It is claimed that by loosening two bolts, the operator can tilt the screen body clear of chutes for making panel changes or can change screening angle to increase screening efficiency for different volumes of material, time required for such change being 15 min.

Starters for Synchronous Motors

IMPORTANT in the operation of a new line of automatic and semi-automatic starters for synchronous motors, announced by Cutler-Hammer, Inc., is a frequency-responsive relay which functions in connection with an adjustable time-delay, thermal-overload relay.

In the case of either heavy overload, reduced line voltage, failure of motor field, or loss of d.c. excitation, the frequency relay disconnects the field switch and permits operation as a squirrel cage motor for a period of about 30 sec., depending upon the setting of the thermal-overload relay. Should normal conditions return within the time adjusted for, the motor will resynchronize and continue in operation; otherwise, it will be disconnected from the line. This frequency relay also controls the field excitation automatically and on the reduced voltage automatic type, it governs the transfer from low starting voltage to full voltage.



CUTLER-HAMMER STARTER PANELS

These new starters are made in sizes from 25 to 500 hp. for 220, 440, 550 and 2200 v. They are made in three types; semi-automatic for reduced voltage, at the left, automatic for reduced voltage and automatic for full voltage, at the right.

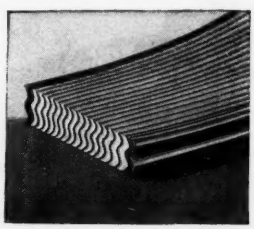
Plumite

DEARBORN CHEMICAL CO. of Chicago, is marketing a product called Plumite described as A Million Little Plumbers in Each Can. This is a chemical solvent to destroy organic matter in drain pipes, keeping them open and free running. It is odorless and the manufacturers state that it will open stopped up drain pipes, also will remove organic discolorations from toilet bowls, without affecting the plumbing and with no fire hazard.

Distribution through regular retail channels is progressing rapidly, also marketing of a line of equally effective cleaners in larger packages, for industrial use.

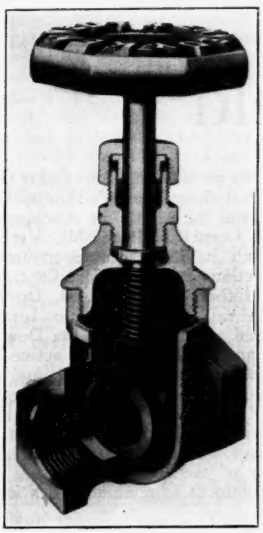
Resilient Gaskets

GUARDIAN GASKETS, developed by the Garlock Packing Co., and patent applied for, are made, as shown of alternate rings of metal and plastic material, corrugated so as to give under pressure and recover as pressure is released, thus, by resilient action adapting themselves to expansion and contraction due to changes of temperature.



Rigid Gate Valve

KENNEDY VALVE MFG. CO., Elmira, N. Y., has placed on the market a new bronze solid-wedge stationary-stem gate valve for 125-lb. steam and 175-lb. water pressure. Features of this valve are: Large bonnet hex placed close to the hub face joint where it screws into the body, which construction makes the valve particularly rigid and assists in removal of the bonnet and stem assembly when the valve is placed where clearances for installation are close. Large number of contact threads between stem and disc which practically eliminates possibility of stripping. Pipe end hexes made heavy, with a large number of threads for tightness of pipe end



KENNEDY BRONZE GATE VALVE

connections without make-up strains on pipe or valve. Stuffing box with gland on all sizes and packing rings of molded square sections, made of a composition which has high graphite content.

MASON REGULATOR CO., announces a new long-life reducing valve, with body cast of chrome-molybdenum steel suitable for initial pressures up to 600 lb. and total temperatures of 750 deg. F. To insure long life in corrosive and severe service, main and auxiliary valves are made of Nitralloy, which resists wire drawing with high pressure drops. Other moving parts are machined from non-corrosive stainless steel, heat treated to provide the necessary degree of hardness to prevent wear.

Leather Belting to Be Sold by Thickness

FOR THE BENEFIT of consumers of belting, The American Leather Belting Association has decided to sell its product by specifications of thickness instead of weight. Inasmuch as leather belting prices are based on thickness, this simplifies and makes easier the checking of each piece of belting to see that the average thickness is as ordered.

Thickness specifications now in effect for first quality leather belting are as follows: Medium single, 10/64 to 12/64 in.; heavy single, 12/64 to 14/64 in.; light double, 15/64 to 17/64 in.; medium double, 18/64 to 20/64 in.; heavy double, 21/64 to 23/64 in.

All values in this table are average thicknesses in inches, and should be determined by measuring 20 coils and dividing the sum of these measurements by 20. In rolls of belting containing less than 20 coils, the average thickness should be determined by measuring one-half of the total number of coils and dividing the sum of these measurements by the number of coils measured.

The classification of light single has been eliminated entirely. No point in either single or double belting shall be more than 2/64 in. thicker or more than 2/64 in. thinner than the average thickness. Second and third quality brands of each manufacturer bear the same relative thickness to the manufacturer's first quality grades as they did in the past under the old ounces per square foot specification.

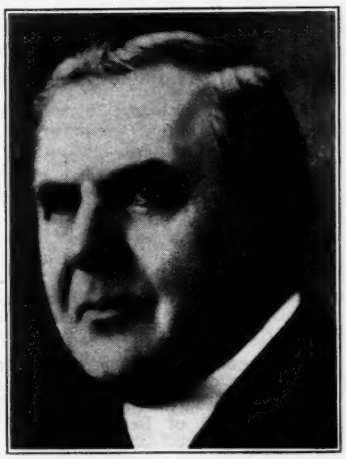
These thicknesses are now in effect and should be used by all buyers of belting in wording their orders, specifying the thickness on the order. If only words light, medium, or heavy appear on the order, these now mean the thickness as per above table and not the weight as formerly.

EXPLOSION PROOF a.c. automatic starters manufactured by the Industrial Controller Division of the Square D Co. have been approved by the Underwriters' Laboratory for use in Class 1, Group D, hazardous locations, such as gasoline refineries and filling stations, dry cleaning plants, paint, varnish and lacquer plants.

Death of Halford Erickson

HALFORD ERICKSON, vice president in charge of operation, Byllesby Engineering and Management Corp., died at ten o'clock Thursday morning, April 7, at his home, 426 Washington Boulevard, Oak Park, Ill.

Mr. Erickson was born July 7, 1864, in Sweden, where he received his early education. He came to the United States in 1884 and attended the university in Minneapolis, sup-



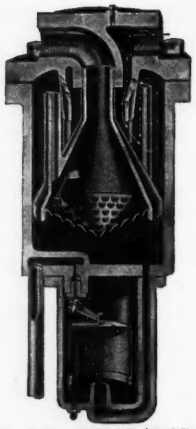
plementing a technical education in the Swedish Military Academy and a liberal general education with special studies in law, economics and engineering, including finance, statistics and similar lines.

Mr. Erickson joined the Byllesby organization in 1918, as vice president of Louisville Gas and Electric Co. He served in that capacity for five years. In January, 1923, he was elected a vice president and director of Byllesby Engineering and Management Corp., in charge of operation of all subsidiary utility properties of Standard Gas and Electric Co.

In addition to being vice president of Byllesby Engineering and Management Corp., Mr. Erickson was vice president, director and member of the executive committee of a number of subsidiary companies in the Standard Gas and Electric Co. system, as well as of Standard Gas and Electric Co. and H. W. Byllesby and Co.

Air Separator and Trap

IN THE DIVIDE Air Separator with trap attached, downward velocity of the air throws any contained water to the top surface of the cone whence it drains to the water chamber. Any remaining water is taken out by the perforated trapping sheet at the bottom of the cone as the air passes down through the tubes and up the inside of the cone to the outlet. Oil, combined with the water, will be carried away with it. From the water chamber the inverted bucket trap discharges it to any desired drain. The separator should be located in that part of the line where the air is coolest, generally near where air is to be used. Sizes are available from ½ in.



DIVIDE AIR SEPARATOR-TRAP COMBINATION

to 2 in., made by The Direct Separator Co., Inc., 218 So. Geddes St., Syracuse, N. Y.

New Commutator Brush

NATIONAL CARBON Co., Inc., Carbon Sales Division, Cleveland, Ohio has recently announced a new electrographitic brush known as National Pyramid Grade No. 234, the characteristic of which is a non-resilient structure—a property which enables the brush to maintain exceptionally firm contact on commutators of high peripheral speed it is claimed. It is stated that excellent commutation, low friction and high carrying capacity combine with the smooth riding properties of this new grade to minimize brush wear and commutator maintenance. The field of application of this new grade as stated is for heavy duty direct current generating and substation equipment.

News From the Field

R. B. FERGUSON, formerly of the Reinbeck, Iowa, Telephone Co., has been appointed manager of the Marengo, Iowa, plant of the Iowa Electric Co., succeeding the late Fred Berry.

JOHN KLINGE, who has been manager of the Peoples Gas and Power Co. plant in Chariton, Iowa, resigned April 1. L. Fischer, formerly of Reedsville, N. C., has succeded him.

WILLIAM S. WILBRAHAM, in charge of the estimating and order department at Lukenweld, Inc., Coatesville, Pa., since this organization was established in 1929, has been appointed assistant manager of sales, and will work directly with Henry H. Peck, manager of sales for Lukenweld, Inc.

COMBUSTION ENGINEERING CORP. announces receipt of contract from the United States Treasury Department, Washington, D. C., for four 2500-hp. Walsh-Weidner sectional header boilers and four C-E multiple retort stokers, super-station type, to be installed in the new Triangle heating plant, Washington, D. C., which will provide heat for various buildings in the new federal building development. Steel-encased boiler settings, water-cooled furnaces and forced and induced draft fans and drives are included. Boilers are for 400 lb. pressure to produce 215,000 lb. of steam an hour continuous and 237,000 lb. maximum, from and at 212 deg. F. Stokers will be 15 retorts wide, 45 tuyers long with projected grate area of 480 sq. ft. each, equipped with double-roll clinker grinders. The consulting engineers on this project are United Engineers and Constructors, Inc., Philadelphia.

JAMES F. OWEN, president, announces the appointment of Bernard F. Weadock as managing director of the National Electric Light Association to succeed Paul S. Clapp, who resigned recently to become vice president of the Columbia Gas and Electric Corp. Mr. Weadock began his career in 1905 in the Corporation Counsel's Office of the City of Detroit and later became assistant corporation counsel, in which capacity he remained until 1912. From 1912 and until 1920 he was general attorney for the Detroit United Lines and acted as assistant to the president, after which he entered into the general practice of law until 1924, when he came to New York as a member of the law firm of J. C. and B. F. Weadock. He severed his connection with this firm late in 1928 to serve as special counsel for the electrical utilities in connection with the Federal Trade Commission's investigation. Mr. Weadock assumed the duties of his new office on April 1 and will also continue to carry on his present work before the Federal Trade Commission.

R. H. BEAUMONT Co. and Beaumont Manufacturing Co., 319 Arch St., Philadelphia, Pa., announce the appointment of Fred B. Lythgoe, 89 Broad St., Boston, Mass. as New England representative for both companies.

ALBERT G. BURKE, Jr., representing Hagan Corpn., Hall Laboratories, Inc., Buromin Co. and Rolland Gardner & Co., has removed his offices to 111 W. Jackson Blvd., Chicago, Ill., retaining the telephone Harrison 1743.

WILLIAM NEWTON AGNEW, traffic manager of the Worthington Pump and Machinery Corp., New York City, since 1910, and also assistant to the president for the past three years, died suddenly April 12 at his home in New York City.

IN ANSWER to inquiries, Bernard F. Weadock, executive director of the National Electric Light Association, has stated that the United Gas Improvement Co., The Philadelphia Electric Co. and the Public Service Corp. of New Jersey, who resigned last year, had rejoined the Association.

JOSEPH DOMAND WARDLE, chief engineer for the Iowa Railway and Light Corp., prominent in the development of that utilities concern, died the evening of April 10 in his home in Cedar Rapids, Iowa., following a week's illness. He was born Dec. 12, 1861, in Lockport, Ill., entered Cornell College, Mt. Vernon, in 1882, and in 1887 became engineer and construction foreman for Capt. S. L. Dows, father of Col. W. G. Dows, pioneer in rail development in Iowa. He continued association with the Dow enterprises and in 1900 became active in the newly organized Cedar Rapids and Southern Construction Co., predecessor of the Iowa Railway and Light Corp. He had been president of the Iowa section of the American Society of Civil Engineers, director of the Iowa Engineering society and prominent in civic activities in Cedar Rapids.

J. MAX LEE, 114 West 17th St., Los Angeles, Cal., has been appointed sales representative in southern California for Dings Magnetic Separator Co. of Milwaukee, Wis.

NORTHERN BLOWER Co., Cleveland, Ohio, has added to its staff Karl Gross, authority on lead burning, lead coating and homogeneous lead work.

STARKWEATHER ENGINEERING Co., Inc., is the new name that has been given to Starkweather & Broadhurst, Inc., of Boston, Mass. The company keeps the same location, 79 Milk St., and the same officers and covers the same field as engineers and contractors.

KAYE & MACDONALD, INC., West Orange, N. J., announces the appointment of Karl G. W. Leaf as direct factory sales representative and manager in charge of sales.

H. F. EDDY has recently been appointed superintendent of Marshall Utilities, Marshall, Minn. These are municipal utilities under the jurisdiction of the city electric light council.

JOHNSON AND KUECHLER, INC., 30 Church St., New York City, has been appointed representative of Ernst & Co., of Newark, N. J.

For the Engineer's Library

DETERMINATION of Ratings for Underground and Aerial Cables, Publication No. 28, a report of the Underground Systems Committee, Engineering National Section, has just been issued by the National Electric Light Association, 420 Lexington Ave., New York, price 30 cents to members, 45 cents to non-members.

The many and varied factors influencing the current carrying capacity of underground cables are dealt with in this report. Standard operating conditions are given for use as a basis in making the temperature calculations when adequate operating data are not supplied. These standard conditions have been used in the preparation of a set of 18 cable rating tables which are included.

Methods of reducing sheath voltages in single conductor cables and the resulting advantages in underground construction are considered. A bibliography of some of the literature relative to the current carrying capacity of buried cables and the heating effect of one buried cable upon another has been included for reference use. The effect of the sun on aerial cables and the problem of determining an accurate ambient temperature is discussed. Field information from several member companies in various geographical districts is given.

BUYERS' GUIDE of Nickel Alloy Steel Products for 1932 has just been published by The International Nickel Co., Inc., 67 Wall St., New York City.

BULLETIN No. 28, describing Southwark-Emery testing machines and giving complete details of their development, construction and uses has just been published by Baldwin-Southwark Corp., Philadelphia, Pa. This 36-page bulletin shows details of typical test curves and uses of stress strain recorders, Universal testing machines from 20,000-lb. to 600,000-lb. capacity, compression testing machines, horizontal testing machines and some special machines.

WATER FILTERS and Filtration Equipment is the title of a new, illustrated 28-page bulletin describing the principles of filtration, the pretreatment of different classes of waters, the various types of chemical feeds, vertical and horizontal pressure filters, concrete and wood gravity, filters, activated carbon filters, etc., published by The Permutit Co., 440 Fourth Ave., New York.

PRACTICALLY all water supplies hold oxygen in solution and such water when heated will actively corrode steel, iron or brass with which it comes into contact, particularly if the water is soft, that is, free from scale-forming impurities. However, all dissolved gases, including oxygen, can be driven from the water by heating it in heaters of the modern, improved deaerating type, which will stop the corrosion entirely unless there be acidity. Acids, if present, can be neutralized by suitable chemical reagents. Means and methods for combating oxygen corrosion of boilers, piping and other apparatus in buildings are the subject of a new publication, No. 1810, distributed by the Cochrane Corp., Philadelphia, Pa.

ILLUSTRATED book issued by Stone & Webster, Inc., 90 Broad St., New York, records the history of the organization and its services to industry and science. A chart sets forth, for the first time, the working relationship between the parent company and its various subsidiaries which function as a unit in a broad field, embracing engineering construction and finance and the ownership and supervision of public utilities.

The original firm of Stone & Webster was founded in 1888 by Charles A. Stone and Edwin S. Webster, with a capital of $4,000. On January 1 this year, according to the balance sheet, assets of Stone & Webster, Inc., exceeded $400,000,000.

The pioneering record of Stone & Webster, according to this book, includes: first commercial use of 1,200-lb. steam, at the Charles Leavitt Edgar Station of the Edison Electric Illuminating Co. of Boston in 1925. The first use of X-ray in examining commercial steel castings for defects was made during this work.

First commercial mercury boiler and turbine was installed for the Hartford Electric Light Company, in 1925. First use of pulverized coal on a large scale instituted in 1917 for the Puget Sound Power & Light Co. First utilization of oil refinery waste as a fuel in combination with a conventional base fuel in a large central station plant was originated in 1930 at the Baton Rouge plant at Louisiana Steam Products, Inc.

CORRECTOFIN is the name given to a new heater, which is adapted for use on any 2-pipe steam, vapor or vacuum system. It is designed for built-in or concealed arrangement, the copper heating element with its finned tubing being placed in the bottom of a steel cabinet which has inlet and outlet grills at the bottom and top. The device and its application are described and illustrated in Bulletin No. 4 issued by the Commodore Heaters Corp., 11 W. 42nd St., New York, N. Y.

FRIDY CAR PULLERS and hoists, made by Fridy Hoist & Machinery Co., Mountville, Pa., are described and illustrated in a 16-p. catalog giving capacities, sizes, weights and a list of users. They are for either electric or gasoline drive with vertical or horizontal capstans and various gear reduction as may be needed. Hoists are also made for belt drive. A late design is a combination drum and capstan car puller of friction type, drum and capstan operating independently, for hauls from a short distance up to 800 ft.

IN A 4-P. BULLETIN, Laclede-Christy of St. Louis describes the characteristics and qualities of its Laclede Mullite refractory, a new development of the company's research laboratory, to give resistance to spalling, to attack by molten slag and to deformation at high temperature.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.

required by the Act of Congress of August 24, 1912, of Power Plant Engineering, published semi-monthly at Chicago, Ill., for April 1, 1932.

State of Illinois, } ss.
County of Cook, }

Before me, a Notary in and for the State and county aforesaid, personally appeared Arthur L. Rice, who, having been duly sworn according to law, deposes and says that he is the Editor of the Power Plant Engineering and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to-wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher, Technical Publishing Co., Chicago, Ill.

Editor, Arthur L. Rice, Chicago, Ill.

Managing Editor, R. E. Turner, Chicago, Ill.

Business Manager, E. R. Shaw, Chicago, Ill.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.)

Technical Publishing Co., Chicago, Ill.
E. R. Shaw, Chicago, Ill.
K. L. Rice, Chicago, Ill.
Madge W. Rice, Wilmette, Ill.
Chas. S. Clarke, Chicago, Ill.
Arthur L. Rice, Chicago, Ill.
R. E. Turner, Chicago, Ill.
A. W. Kramer, Chicago, Ill.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)

There are none.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

TECHNICAL PUBLISHING CO.,
ARTHUR L. RICE, Editor.

Sworn to and subscribed before me this 22nd day of March, 1932.

[Seal.] EDDIE H. KAHL,
Notary Public.

(My commission expires March 21, 1936.)

Power Plant Construction News

Ark., Elaine—Elaine Utilities Co., Elaine, is considering extensions and improvements in power plant, including installation of additional equipment. An expansion and improvement program is also planned for local waterworks. Henry H. Thompson, 3891 Galloway Drive, Memphis, Tenn., heads the company.

Calif., San Francisco—Dairy Delivery Co., 2550 Nineteenth Street, plans construction of a boiler and compressor plant at proposed three-story dairy products distributing plant on Potrero Avenue, entire project estimated to cost over $200,000. William Toepke, 2550 Nineteenth Street, is architect.

Conn., New Britain—Southern New England Ice Co., 48 Edward Street, Hartford, Conn., has approved plans for proposed new ice-manufacturing plant, one-story, 51 x 118 ft., on Elm Street, New Britain, and will proceed with superstructure at once. It will cost close to $40,000, with equipment.

Ga., Manchester—City Council is said to be arranging early call for bids for a filtration plant for municipal water system. Wiedeman & Singleton, Candler Building, Atlanta, Ga., are engineers.

Iowa, Bedford—City Council is arranging date for special election for approving bond issue of $100,000, fund to be used for a proposed municipal electric light and power plant. J. E. Lowell is city clerk.

Iowa, Boone—Iowa Railway & Light Corporation, Cedar Rapids, Iowa, is negotiating for an extension of light and power franchise at Boone and vicinity, and agrees to expend about $400,000 in expansion and improvements in plant and system for local service during next 48 months, with appropriations for work on annual schedule.

Iowa, Lenox—City Council has been authorized by a vote of citizens at a special election to have plans drawn for a municipal electric light and power plant. An appropriation will soon be arranged.

Kan., Kansas City—Board of Public Utilities, Kansas City, is planning installation of boiler equipment and auxiliaries in the municipal electric light and power plant. Expected to ask bids in May. Burns & McDonnell Engineering Co., Interstate Building, Kansas City, Mo., are consulting engineers.

Ky., Middleboro—Union Tanning Co., Middleboro, is said to be planning installation of power equipment in connection with proposed rebuilding of leather tanning plant, recently destroyed by fire with loss of about $40,000.

Mass., Boston—Boston Elevated Railway, 31 St. James Avenue, plans construction of power plant to cost over $200,000, in connection with proposed purchase of property and system of Massachusetts Street Railway Co. at Boston, Revere, Chelsea, Everett and vicinity for total consideration of $2,800,000. Legislature is considering bill to allow for acquisition, with fund of $500,000 for extensions and improvements.

Mass., Malden—Barrett Co., 40 Rector Street, New York, manufacturer of tar products, roofing specialties, plans installation of electric power equipment in proposed new plant on 14-acre tract of land at Malden, entire project estimated to cost over $90,000. Present factory at Everett, Mass., will be removed to new location and capacity increased.

Mich., Sturgis—City Council, Sturgis, has plans nearing completion for a municipal hydroelectric power plant to cost about $90,000. It is expected to begin work this summer. Ayres & Norris, Lewis & May, Ann Arbor, Mich., are consulting engineers.

Mo., Kansas City—Crystal Carbon Ice Co., 805 Chambers Building, Kansas City, is considering construction of a new dry ice-manufacturing plant, estimated to cost over $50,000, with machinery.

Mo., Kansas City—Missouri Power & Light Co., Kansas City, has made application for permission to construct a new transmission line from Madison to Holliday, Mo., and vicinity, with power substation facilities for rural service.

N. Y., Le Roy—Union Steel Chest Corporation, care of Seely F. Pratt, 132 Shoreham Drive, Brighton, N. Y., recently formed by Mr. Pratt and associates with capital of $50,000 and 3000 shares of stock, no par value, plans installation of motors and other power equipment in new plant in Woodward Building, Church Street, Le Roy, where over 25,000 sq. ft., floor space has been leased, for manufacture of steel chests, boxes, and kindred containers.

N. Y., Staten Island—New Method Service Co., Inc., 459 Bay Street, Stapleton, Staten Island, New York, is planning installation of power equipment at mechanical laundry, including 100 to 200 hp. boiler, 100 kw. generator unit and accessories.

Ohio, Akron—Quaker Oats Co., 141 West Jackson Boulevard, Chicago, Ill., plans installation of electric power equipment, hoisting and conveying equipment and accessory apparatus in new grain elevator unit at Akron plant, entire project estimated to cost about $265,000.

Ohio, Eaton—City Council has engaged Fosdick & Hilmer, Union Trust Building, Cincinnati, Ohio, consulting engineers, to prepare plans for proposed municipal electric light and power plant, estimated to cost about $125,000, with equipment.

Okla., Oklahoma City—Sterling Refining Co., care of B. F. Green, Hunt Building, Tulsa, Okla., vice-president and general manager, recently organized to take over plant of Peerless Oil & Refining Co., Oklahoma City, is considering installation of stills and other equipment in connection with expansion and improvement program.

Pa., New Castle—Citizen's Lumber Co. plans installation of motors and other electric power equipment in connection with proposed rebuilding of planing mill, recently destroyed by fire with loss of about $70,000. A. E. Kerr is vice-president and general manager.

Pa., Philadelphia—Collins & Aikman Corporation, Fifty-first Street and Columbia Avenue, plan installation of electric power equipment in proposed addition to plush mill, entire project reported to cost over $60,000. H. M. Wilson Co., 20 South Fifteenth Street, is engineer.

S. C., Ridgeland—Ellis & Quarterman Lumber Co., Ridgeland, plan installation of motors and other power equipment in connection with proposed rebuilding of portion of mill, recently destroyed by fire with loss close to $100,000, including machinery.

Tenn., Knoxville—Knoxville Ice Cream Co., 1020 West Fifth Avenue, plans installation of a 4-ton refrigerating machine with auxiliary equipment in proposed new ice cream-manufacturing plant, entire project to cost close to $40,000. I. C. Levinson heads the company.

Tenn., Memphis—E. L. Bruce & Co., Thomas Street, plan installation of electric power equipment in connection with proposed rebuilding of radio cabinet manufacturing plant, recently destroyed by fire with total loss estimated in excess of $100,000.

Texas, Beaumont—Magnolia Petroleum Co., Dallas, Tex., plans installation of power equipment in connection with proposed rebuilding of oil refining plant at Beaumont, recently destroyed by fire, with loss reported over $200,000.

Texas, College Station—Board of Trustees, Texas Agricultural and Mechanical College, plans installation of motors and other electric power equipment, mechanical and engineering equipment, in proposed four-story petroleum engineering and experiment building, 52 x 186 ft., entire project to cost about $200,000. Dr. F. E. Giesecke, College Station, is architect.

Texas, Dallas—United States Cold Storage Corporation, 2101 West Pershing Road, Chicago, Ill., and 500 East Third Street, Kansas City, Mo., has leased portion of terminal buildings of Santa Fe Railway Co., Dallas, and will occupy for new branch central cold storage and refrigerating plant, reported to cost more than $175,000.

Texas, Texarkana—Butternut Bread Co., Texarkana, A. C Wortham, head, plans installation of steam power equipment, including traveling oven and accessories, in proposed new baking plant, entire project reported to cost about $70,000. Witt, Seibert & Halsey, Texarkana, are architects.

W. Va., Due—Raine Lumber & Coal Co., Clover Lick, W. Va., heretofore known as Raine Lumber Co., J. W. Raine, head, is planning installation of a coal tipple and coal-mining plant on tract of 2000 acres of coal lands at Due, Greenbrier County. Entire project is reported to cost over $75,000.